U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-300 540

Environmental Assessment of Surface Mining Methods: Head-of-Hollow Fill and Mountaintop Removal

Skelly and Loy, Harrisburg, PA

Prepared for

Industrial Environmental Research Lab -Cincinnati, OH

Jul 79

United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Cincinnati OH 45268

EPA-600/7-79-062
July 1979

Research and Development

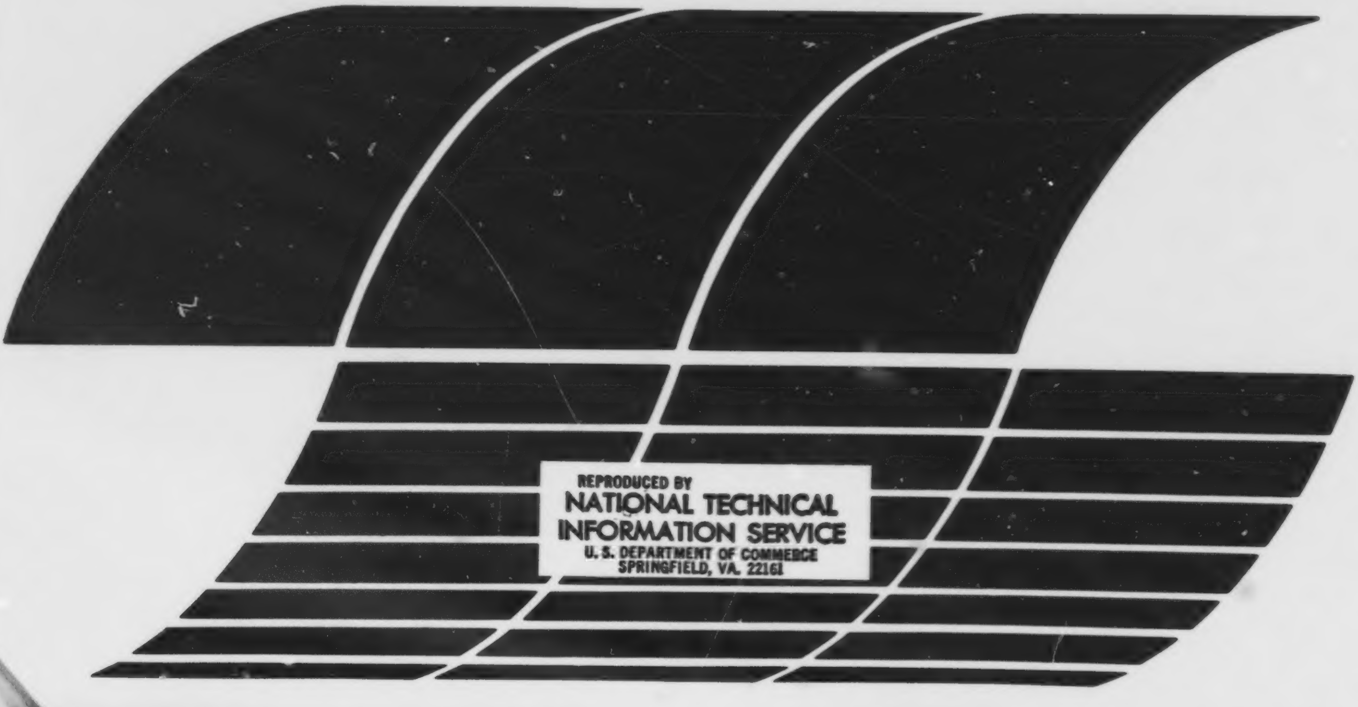
PB 300540

EPA

Environmental Assessment of Surface Mining Methods

Head-of-Hollow Fill and Mountaintop Removal

Interagency Energy/Environment R&D Program Report



REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the INTERAGENCY ENERGY-ENVIRONMENT RESEARCH AND DEVELOPMENT series. Reports in this series result from the effort funded under the 17-agency Federal Energy/Environment Research and Development Program. These studies relate to EPA's mission to protect the public health and welfare from adverse effects of pollutants associated with energy systems. The goal of the Program is to assure the rapid development of domestic energy supplies in an environmentally-compatible manner by providing the necessary environmental data and control technology. Investigations include analyses of the transport of energy-related pollutants and their health and ecological effects; assessments of, and development of, control technologies for energy systems; and integrated assessments of a wide range of energy-related environmental issues.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/7-79-062	2.	3. RECIPIENT'S ACCESSION NO. PB300540
4. TITLE AND SUBTITLE Environmental Assessment of Surface Mining Methods: Head-of-Hollow Fill and Mountaintop Removal		5. REPORT DATE July 1979 issuing date 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Skelly & Loy Engineers-Consultants		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Skelly and Loy 2601 North Front Street Harrisburg, Pennsylvania 17110		10. PROGRAM ELEMENT NO. EHE623 11. CONTRACT/GRANT NO. 68-03-2356
12. SPONSORING AGENCY NAME AND ADDRESS Industrial Environmental Research Laboratory-Cincinnati Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Interim 11/75-1/77 14. SPONSORING AGENCY CODE 600/12

15. SUPPLEMENTARY NOTES

This volume was prepared for Skelly and Loy by John D. Robins and John C. Hutchins

16. ABSTRACT

This study explores the environmental impact of the mining and reclamation techniques employed in West Virginia and Kentucky mountaintop removal and head-of-hollow fill sites. The project is divided into four major phases, the first three of which are discussed in this Interim Report: I. State-of-the-Art Review, II. General Environmental Assessment of West Virginia and Kentucky Mines Sites, III. Intensive Mine Site Monitoring and Environmental Assessment in Both States, and IV. Evaluation and Update of Construction Guidelines.

In addition to a comprehensive literature review completed during Phase I, a series of detailed investigations was conducted at ten mine sites in West Virginia and Kentucky over a period of one year. The purpose of these investigations was to assess the impacts of variable physical factors such as geology, topography, and climatology in relation to the mining and reclamation criteria employed. Study mine site case histories are presented, as well as conclusions and recommendations drawn from data and observations gathered during this course of study.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Overburden	Environmental Assessment	08I	50A
Reclamation	Head-of-Hollow Fills	08M	50D
Soil Stabilization	Highway Waste Disposal Sites	13B	68C
Surface Mining		13M	68D
Water Quality	Mountaintop Removal Mining		89
	Kentucky	48A	91A
	West Virginia	48G	
		48F	

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 223
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE A10-A01

EPA Form 2220-1 (9-73)

☆ U. S. GOVERNMENT PRINTING OFFICE: 1979 — 657-060/5348

EPA-600/7-79-062
July 1979

ENVIRONMENTAL ASSESSMENT OF SURFACE MINING METHODS: HEAD-OF-HOLLOW FILL AND MOUNTAINTOP REMOVAL

Interim Report

by

Skelly and Loy
Engineers - Consultants
Harrisburg, Pennsylvania 17110

Contract No. 68-03-2356

Project Officer

John F. Martin
Extraction Technology Branch
Industrial Environmental Research Laboratory
Cincinnati, Ohio 45268

INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

i.a

DISCLAIMER

This report has been reviewed by the Industrial Environmental Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-CI) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This interim report addresses the current state-of-the-art for the mountaintop removal and head-of-hollow fill method of surface mining. The report presents a general environmental assessment of these techniques for several West Virginia and Kentucky mine sites, and evaluates the environmental acceptability of this mining method in view of its effectiveness in minimizing off-site environmental degradation and enhancing land use of reclaimed areas.

This report will be of interest to the mining industry and State and Federal agencies associated with coal extraction. For further information contact the Extraction Technology Branch of the Resource Extraction and Handling Division.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

This study explores the environmental impact of the mining and reclamation techniques employed in West Virginia and Kentucky mountaintop removal and head-of-hollow fill sites. The project is divided into four major phases, the first three of which are discussed in this Interim Report.

I. State-of-the-Art Review
II. General Environmental Assessment of West Virginia and Kentucky Mine Sites
III. Intensive Mine Site Monitoring and Environmental Assessment in Both States
IV. Evaluation and Update of Construction Guidelines

In addition to a comprehensive literature review completed during Phase I, a series of detailed investigations was conducted at ten mine sites in West Virginia and Kentucky over a period of one year. The purpose of these investigations was to assess the impacts of variable physical factors such as geology, topography, and climatology in relation to the mining and reclamation criteria employed. Study mine site case histories are presented, as well as conclusions and recommendations drawn from data and observations gathered during this course of study.

This report was submitted in fulfillment of Contract Number 68-03-2356 by Skelly and Loy under the sponsorship of the U.S. Environmental Protection Agency. This interim report covers the first year (November 4, 1975 to January 1, 1977) and work was completed as of March 1, 1977, however the study is not complete until February 4, 1979.

CONTENTS

Foreword . . . iii
Abstract . . . iv
Figures . . . vi
Tables . . . x
Conversion Table - English to Metric . . . xv
Acknowledgment . . . xvi

1. Introduction . . . 1
2. Conclusions . . . 6
3. Recommendations . . . 9
4. Background Information . . . 16
5. Phase I - State-of-the-Art Review . . . 25
    Mountaintop removal technique . . . 25
    Head-of-hollow fill disposal method . . . 30
6. Phase II - General Site Assessment . . . 53
    Site selection criteria . . . 53
    West Virginia case histories . . . 56
    Kentucky case histories . . . 93
7. Discussion of Study Findings . . . 135
8. Project Status - Phase III . . . 193

References . . . 198
Appendix . . . 199

FIGURES

Number		Page
1	Illustration of recommended modification for head-of-hollow fills	13
2	Cross sections of recommended modification for head-of-hollow fills	14
3	Cross section D-D' alternate toe stabilization designs for head-of-hollow fills	15
4	West Virginia head-of-hollow fill	31
5	Cross section of typical West Virginia head-of-hollow fill	32
6	Kentucky head-of-hollow fill	38
7	Cross section of typical Kentucky head-of-hollow fill	39
8	Sequence of Kentucky head-of-hollow fill construction not utilizing fill pushdown techniques	42
9	Sequence of Kentucky head-of-hollow fill construction meeting 48 hour pushdown requirements	44
10	Temperature records in 1976 by month for mine site BA	57
11	Total precipitation in 1976 by month for mine site BA	58
12	Temperature records in 1976 by month for mine site HA	64
13	Total precipitation in 1976 by month for mine site HA	65

FIGURES (Continued)

Number Page

14 Temperature records in 1976 by month for mine site MA 71

15 Total precipitation in 1976 by month for mine site MA . . 72

16 Temperature records in 1976 by month for mine site OA 80

17 Total precipitation in 1976 by month for mine site OA . . 81

18 Temperature records in 1976 by month for mine site PA 87

19 Total precipitation in 1976 by month for mine site PA . . 88

20 Temperature records in 1976 by month for mine site EA 94

21 Total precipitation in 1976 by month for mine site EA . . 95

22 Temperature records in 1976 by month for mine site FA 102

23 Total precipitation in 1976 by month for mine site FA . . 103

24 Temperature records in 1976 by month for mine site GA 111

25 Total precipitation in 1976 by month for mine site GA . . 112

26 Typical rock sequence for mining hazard no. 5A 114

27 Temperature records in 1976 by month for mine site IA 121

FIGURES (Continued)

Number		Page
28	Total precipitation in 1976 by month for mine site IA . . .	122
29	Temperature records in 1976 by month for mine site KA	128
30	Total precipitation in 1976 by month for mine site KA . .	129
31	Applecore	144
32	Mountaintop site	144
33	Excavated pond	145
34	Gabion dam	145
35	Clearing and grubbing a mine site	146
36	Windrowed vegetation	146
37	Loader/truck combination	146
38	Power shovel/truck combination	147
39	Pan scraper	148
40	Dragline	148
41	Typical blasting	149
42	Dust control	149
43	Mountaintop lake	150
44	West Virginia hollow fill	152

FIGURES (Continued)

Number		Page
45	Kentucky hollow fill	153
46	Rock core drain construction	153
47	Elevated rock core	154
48	Depressed rock core	154
49	Kentucky fill placement by end-dump	155
50	Slip area in hollow fill	156
51	Erosion of outslope in West Virginia	156
52	Erosion of hollow fill in Kentucky	157
53	Long uninterrupted outslope in a Kentucky fill	157
54	Kentucky fill outslope benched for erosion protection	158
55	Regrading a hollow fill	158
56	Revegetating by hydroseeder	159
57	Revegetated mountaintop site	159
58	Revegetated head-of-hollow fill	160
59	Water quality monitoring equipment	161
60	Stream flow monitoring equipment	161
61	Typical internal structure of hollow fills	169

TABLES

Number		Page
1	Description of General Assessment Sites	5
2	Hydrologic Data - West Virginia Study Region	19
3	Hydrologic Data - Kentucky Study Region	23
4	Specifications for Temporary Slope Drains	48
5	Kentucky Highway Erosion Control	52
6	Water Quality at Mine Site BA's Sediment Pond	61
7	Climatological Conditions During Water Quality Sampling Periods at Mine Site BA	62
8	Equipment Used at Mine Site HA	66
9	Water Quality at Mine Site HA's Sediment Pond	69
10	Climatological Conditions During Water Quality Sampling Periods at Mine Site HA	70
11	Overburden at Mine Site MA	73
12	Equipment Used at Mine Site MA	75
13	Water Quality at Mine Site MA's Sediment Pond	77
14	Climatological Conditions During Water Quality Sampling Periods at Mine Site MA	78
15	Equipment Used at Mine Site OA	82
16	Water Quality at Mine Site OA's Sediment Pond	84

TABLES (Continued)

Number Page

17 Climatological Conditions During Water Quality Sampling Periods at Mine Site OA 85

18 Equipment Used at Mine Site PA 89

19 Water Quality at Mine Site PA's Sediment Pond 91

20 Climatological Conditions During Water Quality Sampling Periods at Mine Site PA 92

21 Overburden at Mine Site EA 96

22 Equipment Used at Mine Site EA 97

23 Water Quality at Mine Site EA's Sediment Pond 99

24 Climatological Conditions During Water Quality Sampling Periods at Mine Site EA 100

25 Overburden at Mine Site FA 104

26 Equipment Used at Mine Site FA 106

27 Water Quality at Mine Site FA's Sediment Pond 108

28 Climatological Conditions During Water Quality Sampling Periods at Mine Site FA 109

29 Overburden at Mine Site GA 113

30 Equipment Used at Mine Site GA 116

31 Water Quality at Mine Site GA's Sediment Pond 118

TABLES (Continued)

Number		Page
32	Climatological Conditions During Water Quality Sampling Periods at Mine Site GA	119
33	Equipment Used at Mine Site IA	123
34	Water Quality at Mine Site IA's Sediment Pond	125
35	Climatological Conditions During Water Quality Sampling Periods at Mine Site IA	126
36	Equipment Used at Mine Site KA	131
37	Water Quality at Mine Site KA's Sediment Pond	133
38	Climatological Conditions During Water Quality Sampling Periods at Mine Site KA	134
39	Advantages and Disadvantages of Mountaintop Removal Mining in West Virginia and Kentucky	136
40	Advantages and Disadvantages of West Virginia's Head-of-Hollow Fill Construction Techniques	138
41	Advantages and Disadvantages of Kentucky's Head-of-Hollow Fill Construction Techniques	141
42	Areas of Environmental Impact Associated with Head-of-Hollow Fills	143
43	West Virginia Mountaintop Site Assessment.	162
44	Kentucky Mountaintop Site Assessment	163
45	West Virginia Head-of-Hollow Fill Site Assessment . . .	164

TABLES (Continued)

Number Page

46 Kentucky Head-of-Hollow Fill Site Assessment 166

47 Fill Characteristics for Mine Site BA 171

48 Fill Characteristics for Mine Site HA 172

49 Fill Characteristics for Mine Site MA 173

50 Fill Characteristics for Mine Site OA 174

51 Fill Characteristics for Mine Site PA 175

52 Fill Characteristics for Mine Site EA 176

53 Fill Characteristics for Mine Site FA 177

54 Fill Characteristics for Mine Site GA 178

55 Fill Characteristics for Mine Site IA 179

56 Fill Characteristics for Mine Site KA 180

57 Water Quality Data General Assessment Sites (West Virginia Influent) 181

58 Water Quality Data General Assessment Sites (West Virginia Effluent) 182

59 Water Quality Data General Assessment Sites (Kentucky Influent) 183

60 Water Quality Data General Assessment Sites (Kentucky Effluent) 184

TABLES (Continued)

Number		Page
61	Summary of Effluent Key Mine Drainage Parameters . .	185
62	Summary of Effluent Metal Analyses of Mine Drainage . .	186
63	Summary Description of West Virginia Highway Disposal Sites (Hollow Fills)	189
64	Alternative Uses of Some Reclaimed Surface Mines . . .	191
65	Time Table of Events for Mine Site LA	193
66	Water Quality Analyses	195
67	Time Table of Events for Mine Site SA	197
68	Climatological Conditions for Mine Site FA	199
69	Climatological Conditions for Mine Site GA	200
70	Climatological Conditions for Mine Site IA	201
71	Climatological Conditions for Mine Site HA	202
72	Climatological Conditions for Mine Site MA	203

CONVERSION TABLE - ENGLISH TO METRIC

Multiply (English Units)		by		To Obtain (Metric Units)
English Unit	Abbreviation	Conversion	Abbreviation	Metric Unit
acre	ac	0.4047	ha	hectares
acre-feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram-calories
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555 (°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
inches	in	2.54	cm	centimeters
pounds	lb	0.454	kg	kilograms
mile	mi	1.609	km	kilometer
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
ton (short)	ton	0.907	kkg	metric ton (1000 kilograms)
yard	yd	0.9144	m	meter

* Actual conversion, not a multiplier.

ACKNOWLEDGMENT

The data presented within this report would not have been possible without the unprecedented cooperation provided by the personnel at the study mine sites. Because these companies prefer to remain anonymous, individuals or company affiliation will not be identified; we would, however, like those involved in this study to know that their help during the past year is gratefully acknowledged.

A special thanks to Mr. Ben Greene, Mr. William Raney, and Mr. James Pitsenbarger of the West Virginia Department of Natural Resources Division of Reclamation and to Mr. Ralph Waddle, Mr. Vernal Chaffins, and Mr. Edward Boggs of the Kentucky Department for Natural Resources and Environmental Protection for their continued assistance throughout this project.

Project Officers for the U.S. Environmental Protection Agency during this past year were Mr. Elmore C. Grim and Mr. John F. Martin.

SECTION 1

INTRODUCTION

It is encouraging that, as the United States celebrates two hundred years of progress and development, we are finally realizing that our abundant natural resources are limited and will someday run dry. This is a dramatic change in attitude from the early years of our country, when we used and abused our resources without restraint. The rationale of this philosophy during early exploration and development of the nation is well documented; however, recent fluctuations in the availability of energy resources have brought the inherent long term problems associated with a "cowboy economy" to the attention of each citizen. Personal shortages coupled with man's new perspective of spaceship Earth have led to a growing grassroots concern for the economic and environmental aspects of energy development, distribution and consumption.

In response to its current energy supply dependence on foreign nations, the United States has undertaken the prodigious task of attaining self-sufficiency as soon as possible. Necessarily, a portion of the drive for self-sufficiency is aimed at development of new energy sources or innovative methods for low entropy utilization of existing resources. Until these breakthroughs occur, however, we are forced to rely on existing fuel acquisition and utilization technologies.

It is imperative that energy resource recovery of established reserves be maximized to avoid intensifying the already critical situation. Coal is our nation's most abundant energy source. Measured reserves in Appalachia amount to 106.6 billion metric tons (117.6 billion tons), 61% of the coal resources found in eastern United States. Due to environmental constraints, extraction of coal is in danger of being curtailed in the steep-sloped regions of West Virginia (which contain 33% of Appalachia's reserves), and Kentucky (with 22% of Appalachia's reserves).

Conventional contour stripping techniques are now under close scrutiny and could be abolished in some of the steeper terrain common to these areas. It cannot be denied: this mining method, as employed in the past, created serious environmental problems. General practices employed deposition of overburden material (spoil) beyond the low wall in large unconsolidated piles on the steep hillside. Spoil, thus exposed to erosion and weathering, allowed sediment, acid and other toxins to wash into adjacent streams. Landslides resulted in destruction of downslope vegetation and loss of spoil material necessary for reclamation.

In addition to the environmental considerations, large untapped coal reserves resulting from the uneconomical stripping ratios of contour mining techniques is a major concern. Quite often, due to fluctuating coal market conditions and cash flow problems, economics dictated the abandonment of contour mine sites as overburden depths increased. This practice resulted in unsightly "applecores" or "biscuits" of isolated mountaintops completely surrounded by highwalls. When the area is reclaimed, subsequent coal extraction is costly and unattractive. Auger mining can recover a very small amount of this trapped resource; however, with current practices, this would render mining the remaining portion of the seam unfeasible.

In 1967 a new mining method - mountaintop removal - was first employed at a large operation in West Virginia. Mountaintop removal was designed to minimize the environmental impact of contour mining while meeting the requirements of current surface mining regulations. Essentially, it makes possible total recovery of the coal seam by removal of all overburden.

The large volumes of spoil resulting from mountaintop removal require special handling to protect the environment. Head-of-hollow fill disposal was developed to provide storage space for the excess overburden. Use of this fill method permits construction of a large, stable area rather than unsightly sinuous bands of unstable, highly erodable spoil outslopes.

Despite the fact that head-of-hollow fill construction and mountaintop removal methodologies have been in use for a number of years throughout southern West Virginia and eastern Kentucky, their environmental effects have never been fully investigated. A major goal of this study is to assess the environmental impacts common to these associated techniques, and to evaluate the reclamation process. A second and equally important objective is the development of guidelines for environmentally sound mountaintop removal mining and head-of-hollow fill construction based on evaluations of premine planning, site selection criteria, operating procedures, reclamation plans, and sediment and erosion control. Final recommendations for both techniques will provide guidelines, which, if properly employed, will minimize off-site environmental degradation and produce usable mountaintop land.

SCOPE

The study, Environmental Assessment of Surface Mining Methods: Head-of-Hollow Fill and Mountaintop Removal, is divided into five (5) phases:

I Technical Review of Current State-of-the-Art
II General Environmental Assessments of West Virginia and Kentucky Mine Sites
III Intensive Environmental Assessments of Mine Sites in West Virginia and Kentucky
IV Evaluation and Update of Guidelines
V Final Report

This Interim Report presents study findings for Phases I and II, and defines project status for Phases III and IV.

STUDY DEVELOPMENT

Phase I - State-of-the-Art Review

A prerequisite for any research investigation is an in-depth understanding of existing technology and previous research efforts. Phase I was divided into three areas of effort:

- Collection of background information on techniques
- Land use evaluation
- Primary field evaluation

For ease of presentation and understanding, the results of this review have been incorporated into two sections:

Section 4 Background Information
  - Physical Description of the West Virginia Study Region
  - Physical Description of the Kentucky Study Region

Section 5 Phase I - State-of-the-Art
  - Mountaintop Removal Technique
  - Head-of-Hollow Fill Spoil Disposal Method

Physical conditions in the coal regions of West Virginia and Kentucky which have necessitated the development and utilization of these two innovative techniques are described in Section 5. In addition to the surface mining industry, highway construction divisions of both states have used head-of-hollow fills during interstate highway construction projects. A comparative evaluation will be made between methods of spoil disposal used by the states and those used by industry.

Phase II - General Site Assessment

General site assessments have been conducted at ten mining operations for a period of one year. These sites were selected from a group of 26 possible coal and highway operations in the steep-sloped terrain of southern West Virginia and eastern Kentucky. A brief description of each mine is presented in Table 1. Study sites at the time of selection were in various stages of construction, enabling evaluation of all aspects of planning, mining, fill construction and reclamation, particularly as they relate to the environmental assessment at each site.

Periodic field visits in Phase II were conducted for environmental evaluation of each mine site with respect to water quality, land use and socioeconomic considerations. The results and discussion of these assessments are presented in Section 6.

TABLE 1. DESCRIPTION OF GENERAL ASSESSMENT SITES

MINE SITES	LOCATION		SIZE*			TYPE MINE		COAL SEAM		HEAD-OF-HOLLOW FILL	
	West Virginia	*Kentucky*	*A*	*B*	*C*	*Mountaintop Removal*	*Contour Strip*	*Single Seam*	*Multiple Seams*	*No*	*Yes*
BA	X				X	X			X		X
HA	X			X		X			X		X
MA	X		X			X		X			X
OA	X		X			X			X		X
PA	X		X			X		X			X
EA		X			X	X			X		X
FA		X		X		X			X		X
GA		X		X			X	X			X
IA		X			X	X			X		X
KA		X		X			X		X		X

*A = ≤180,000 metric Ton/Year
B = > A ≤450,000 metric Ton/Year
C = > B ≤1,360,000 metric Ton/Year

SECTION 2

CONCLUSIONS

- Mountaintop removal mining is an environmentally desirable surface mining technique in the steep sloped terrain of southwestern West Virginia and eastern Kentucky when conducted in compliance with existing reclamation criteria.

- Head-of-hollow fill reclamation can reduce adverse environmental impacts occasionally associated with other reclamation practices such as contour regrading in steep terrain or downslope spoil casting. Specifically, these improvements are realized in erosion and sedimentation control, spoil stabilization, revegetation success and land use potential.

- Land use potential can be dramatically improved when mountaintop removal mining is accompanied by well-designed and constructed head-of-hollow fills.

- Successful head-of-hollow fill reclamation is dependent upon a number of variables including fill site topography, spoil characteristics and composition, construction techniques, fill compaction, internal and external drainage systems, final face slope, and revegetation techniques, as well as intended land use. Various construction techniques can be successfully employed if adequate safeguards are provided for these physical constraints.

- Carrying the rock core drainage system to the surface of West Virginia head-of-hollow fill operations is expensive, may serve little purpose after construction is completed, and severely restricts the land use potential of the completed site.

- Kentucky's head-of-hollow fill reclamation regulations are not as restrictive as West Virginia's. Consequently, given the same mining conditions, the Kentucky operators must take more care during construction to achieve the same degree of reclamation success.

- Due to the nature of spoil material and fill placement techniques in West Virginia fills, particle alignment will tend to be perpendicular to the typical failure plane, a desirable construction feature. In normal Kentucky end-dumped fills the particle alignment will tend to be in the direction of the failure plane, offering less resistance to slippage.

- Kentucky's requirement for reducing the outslope in hollow fills every 48 hours may effectively eliminate the natural formation of an underdrainage system by mixing fine materials with the large french drain forming spoil. This will tend to clog any drain which is formed.

- Kentucky fill drainage system efficiency may be reduced further if a high percentage of shale is permitted in the bottom of the fill mass. Rapid decomposition of shale in the underdrain causes the same type of clogging and failure as does the fine grained spoil.

- Woody vegetation removed from the mine or hollow fill area is frequently windrowed between the toe of the fill and its associated sedimentation pond. However, carelessly placed vegetation may be buried by fill material, which may lead to subsequent failure of the fill mass.

- Directing surface water runoff through a rock core (West Virginia) in head-of-hollow fill sites appears to have a filtering effect, thereby limiting the suspended solids concentration of drainage entering the sediment pond. This can be beneficial to pond maintenance.

- Sedimentation basins in both West Virginia and Kentucky are frequently far removed from the actual mining. As a result, drainage areas and influent water volumes are significantly increased, which causes either a decrease in detention time and settling efficiency, or requires a much larger pond capacity.

- Although West Virginia surge ponds located at the head of the rock core are not intended to retain water for long periods of time, those constructed in clay material often do just this. In such cases, stability problems occur from pond seepage which slowly saturates the fill, thus reducing particle integrity or causing direct seepage through the fill face.

- During mining, sediment control is accomplished by diverting all surface water through hollows where sediment ponds have been constructed. In West Virginia, water passing down a hollow fill site will have little erosion impact due to the rock core; however, water draining over a Kentucky fill can cause serious erosion of the fill.

- Rock cores protruding above the fill mass can contribute to fill face erosion if the surface of the core becomes silted at the bench-core interface. This malfunction of the water diversion system causes water to pond on the bench and then flow down the fill face.

- Long uninterrupted slopes of the typical Kentucky hollow fill present a greater erosion potential than the steeper but shorter benched slopes of the West Virginia fills.

- Greater precautions for erosion control must be taken in Kentucky during fill construction, because the unvegetated slope is exposed to possible erosion for long periods due to construction techniques. In West Virginia each lift is revegetated immediately upon fill completion thus stabilizing the surface; however, in Kentucky, the entire fill must be completed before revegetation begins.

- Ultimate stability of West Virginia and Kentucky head-of-hollow fills are unknown. Further tests need to be conducted such as compaction and consolidation tests, grain size distribution, Atterburg limits, shear strength and water movement within the fill.

- Regulations and construction guidelines for waste disposal sites (head-of-hollow fills) of the highway industry are less restrictive than surface mining requirements in both West Virginia and Kentucky. Rock cores are not required in West Virginia highway fills, although a surface riprap drain is generally provided as an erosion control system.

SECTION 3

RECOMMENDATIONS

SITE SELECTION

- Hollow fill sites should be free of spring or wet weather seeps, unless the mining plan provides for lateral drains to be constructed from the wet area to the main underdrain.

- Slope of the hollow at the proposed toe of the fill should not exceed 10° unless additional stabilizing structures, such as keyway cuts and/or rock buttresses are utilized.

SITE PREPARATION

- Sediment control ponds should be constructed near the proposed toe of the fill.

- Clearing and grubbing should take place just ahead of the spoil placement. All organic material must be removed from the fill zone, not buried within it.

FILL CONSTRUCTION

- If the toe of the fill lies on steep terrain with "V"-shaped valleys (Figures 1 and 2), a keyway cut should be installed at the toe to increase stability and minimize the risk of failure. Its trapezoidal shape and minimum dimensions are illustrated in Figure 3 part A:
    Depth: 1.5 meters (5 ft.) into consolidated material
    Side slopes: No flatter than 1½ : 1
    Bottom width: No less than 3 meters (10 ft.)

  In fills $<$765,000 cubic meters, an alternate design to the trapezoid keyway cut is the benched fill shown in Figure 3 part B:
    Side slope: No flatter than 1½ : 1
    Bottom width: No less than 3 meters (10 ft.)

  Regardless of design shape, the keyway should be filled with durable sandstone rock for maximum effectiveness. Where detailed soils analyses indicate adequate foundation stability, the keyway cut may be eliminated.

- In addition to a keyway cut, in large head-of-hollow fill operations (>765,000 cubic meters - 1.0 million cubic yards) a rock toe buttress should be constructed to further stabilize the fill mass.

- A rock underdrainage system should be constructed along the hollow's natural drainway with lateral drains to each spring or seep.
    1. In fills containing less than 765,000 cubic meters or 1,000,000 cubic yards of predominantly sandstone, the main drain dimensions should be not less than 2.4 meters wide by 1.2 meters high (8 ft. by 4 ft.); if overburden is predominantly shale, the underdrain should be not less than 4.9 meters by 2.4 meters (16 ft. by 8 ft.).
    2. In fills containing more than 765,000 cubic meters of predominantly sandstone, the main drain dimensions should not be less than 4.9 meters by 2.4 meters (16 ft. by 8 ft.); if overburden is predominantly shale, the underdrain should not be less than 4.9 meters by 4.9 meters (16 ft. by 16 ft.). These underdrains (both main and lateral) should be designed by a qualified engineer based on assessment of site specific geologic and physical factors.

  All underdrains should be of durable rock with no more than 10% of a size <0.3 meters (12 inches) and no material larger than 25% of the drain width.

  (NOTE: The preceding size restrictions are designed to provide assured drainage with relatively little control, and are, therefore, considerably larger than would be required should the operator elect to construct a more carefully designed underdrainage system such as a graded rock system with the requisite filter blanket.)

- Spoil placement can be accomplished as follows:
    1. > 65% sandstone, material can be sidedumped and need not be compacted but should be worked in level benches at the end of each shift.
    2. < 65% sandstone, material can be sidedumped, but should be picked up at bottom of dump point and placed on fill bench in 1.2 meters (4 ft.) layers and compacted.
    3. In steep terrain with >90% sandstone overburden, underdrainage systems can be constructed through natural segregation by sidedumping.

    (NOTE: Sidedumping can only be accomplished effectively in relatively steep terrain).

- When fills are constructed by dumping from a higher elevation, there should be a good mix of end dumping and sidedumping (spoil tends to be plate shaped and dumping from one location will align material in a single plane creating slip failure planes).

- The fill should be benched for increased stability as shown in Figure 2, sections B through BB':

  Vertical lift height: 15 meters (50 ft.) maximum
  Bench width: 6 meters (20 ft.) minimum
  Slope toward diversion ditches: 3-5%
  Slope toward fill mass: 3-5%
  Surface stabilization: revegetation concurrent with construction

- All surface drainage should be diverted away from the fill site to diversion ditches constructed in undisturbed material — these ditches should be protected by riprap or other means in steep grades such as outslopes.

- The preceding recommends guidelines for the construction of environmentally stable head-of-hollow fill spoil disposal. Two points must be emphasized however: 1) each mine site is physically different and any adopted criteria should provide for alternative construction techniques considerate of these physical variations; and 2) these criteria should allow flexibility in the surface reclamation for sculpting the final landform to harmonize with the local environment and regional land use plan. The stability of a fill mass is generally dependent upon four factors — drainage control, fill site topography, characteristics of the spoil, and method of placement — with the latter three being site variable. Therefore, the mine operator should have the option to choose the construction method which will meet the objective of creating an environmentally sound fill in the most cost-efficient manner, as dictated by specific mine site conditions.

- There are numerous construction and reclamation schemes which can be successfully utilized depending upon site specific physical factors and ultimate land use goals and objectives. Regardless of the particular scheme employed, the fill should be designed by a qualified engineer based on analyses of the composition of spoil materials and the physical character of the proposed fill site.

COMMENTS CONCERNING CURRENT OPERATIONS IN WEST VIRGINIA AND KENTUCKY

- In mining operations where overburden is comprised largely of shales or clays (>35%), the internal drainage system is crucial for ultimate fill stability. Spoil should be hauled to the fill lift and compacted by equipment, with the most durable sandstone selected for placement into the drainage system (rock core or french drain).

- In Kentucky fill sites, water diverted from the active mine site should not be permitted to run through the fill unless conveyed by a riprap channel or pipe. These fills are unconsolidated and easily eroded, thus acute environmental damage can occur.

- Long uninterrupted fill slopes, generally occurring in Kentucky, should be avoided by cutting diversion ditches (10^{o} maximum slope) across the fill face, thus reducing the erosion potential of these long slopes.

- Vegetative material should not be windrowed immediately adjacent to the anticipated final outslope of the hollow fill. Quite often this material becomes covered during the fill operation, thereby decreasing fill mass stability.

- Surge ponds placed at the head of the West Virginia hollow fill cores should be constructed to completely drain through the core. Any water retained in this pond can only cause instability by saturating fill material or creating seeps within the fill.

- Sedimentation basins should be constructed in close proximity to the actual mining operation, thereby reducing the drainage area and volume of water through the pond.

- Reclamation schemes for mountaintop removal mine sites should be carefully reviewed by the responsible regulatory agencies to assure that they are considerate of the regional aesthetic environment. Unless the cumulative effect of individual reclamation plans are considered, we run the risk of creating visually monotonous ranges of leveled mountaintops in areas characterized by their innate rustic beauty — a region that has very limited potential for development of these leveled areas.

- More diligent use should be made of the artist/designer in the final reclamation scheme to sculpture the land to a form that harmonizes with the surrounding environment while reflecting or expressing the function or after-use of the site.

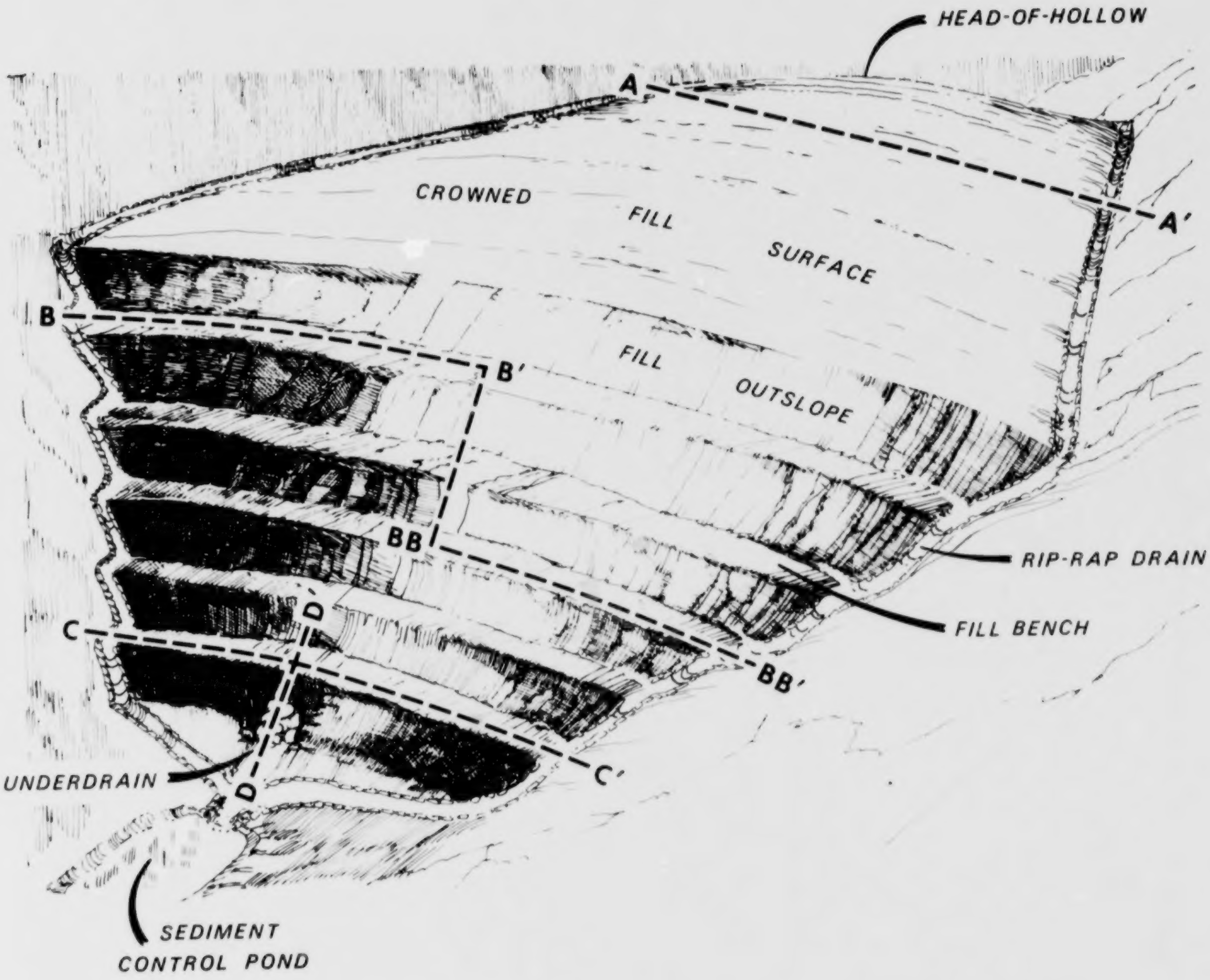
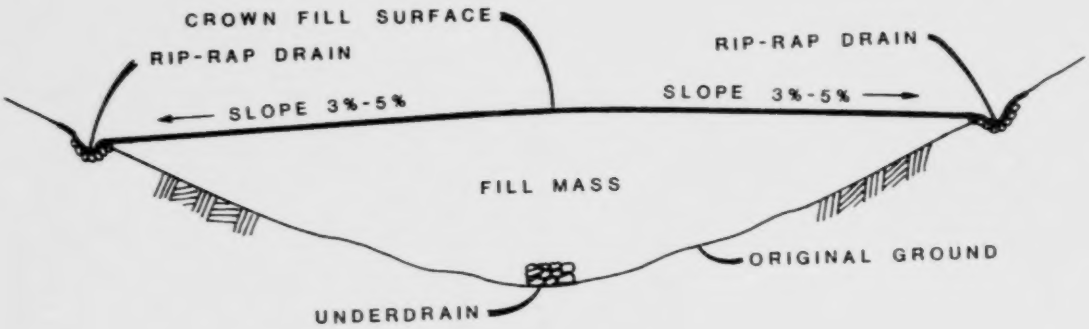
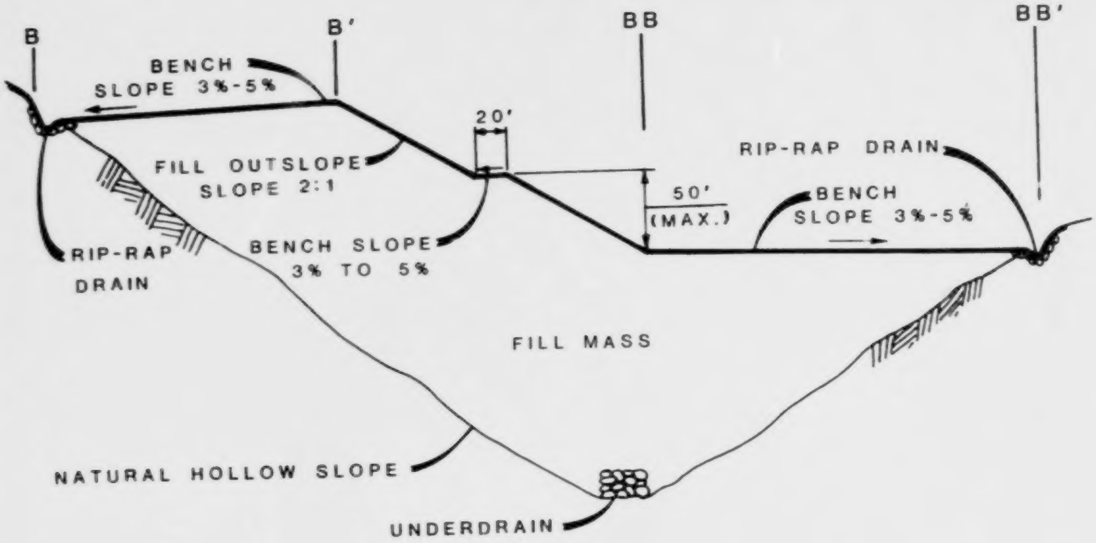

HEAD-OF-HOLLOW
A
A'
CROWNED FILL SURFACE
B
B'
FILL OUTSLOPE
BB
BB'
RIP-RAP DRAIN
FILL BENCH
C
C'
D'
D
UNDERDRAIN
SEDIMENT CONTROL POND

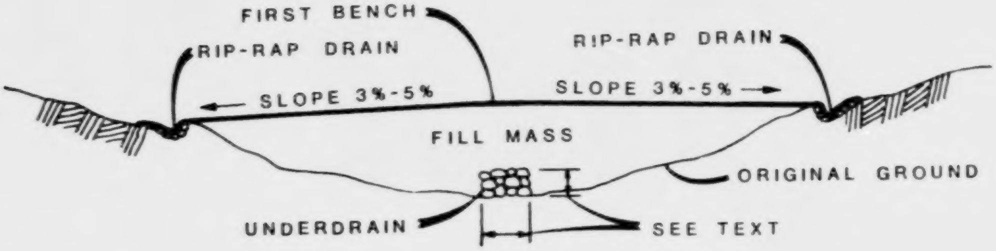
Figure 1. Illustration of recommended modification for head-of-hollow fills.


CROWN FILL SURFACE
RIP-RAP DRAIN
RIP-RAP DRAIN
SLOPE 3%-5%
SLOPE 3%-5%
FILL MASS
ORIGINAL GROUND
UNDERDRAIN

SECTION A-A'

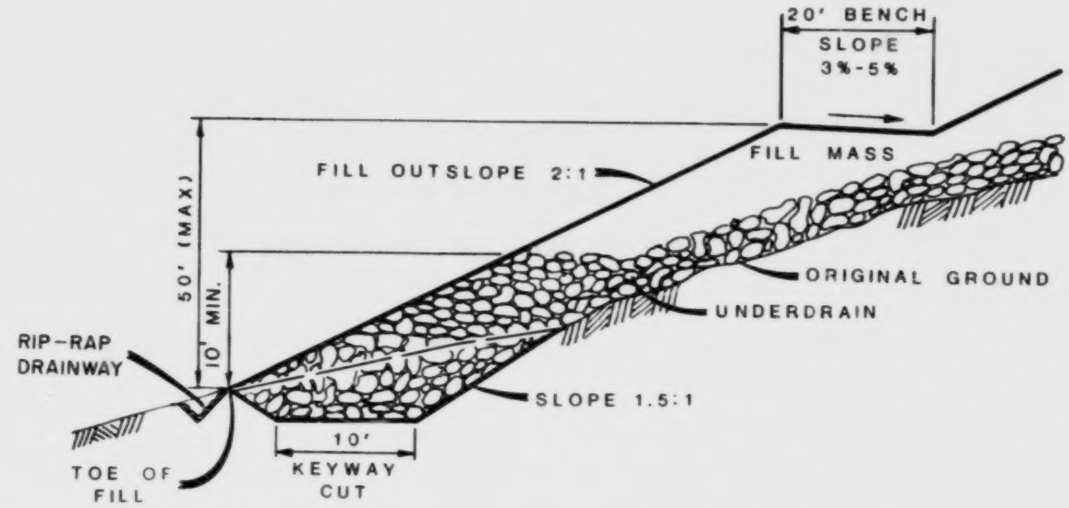

B
B'
BB
BB'
BENCH
SLOPE 3%-5%
20'
FILL OUTSLOPE
SLOPE 2:1
RIP-RAP DRAIN
50'
(MAX.)
BENCH
SLOPE 3%-5%
RIP-RAP
DRAIN
BENCH SLOPE
3% TO 5%
FILL MASS
NATURAL HOLLOW SLOPE
UNDERDRAIN

SECTION B THRU BB'

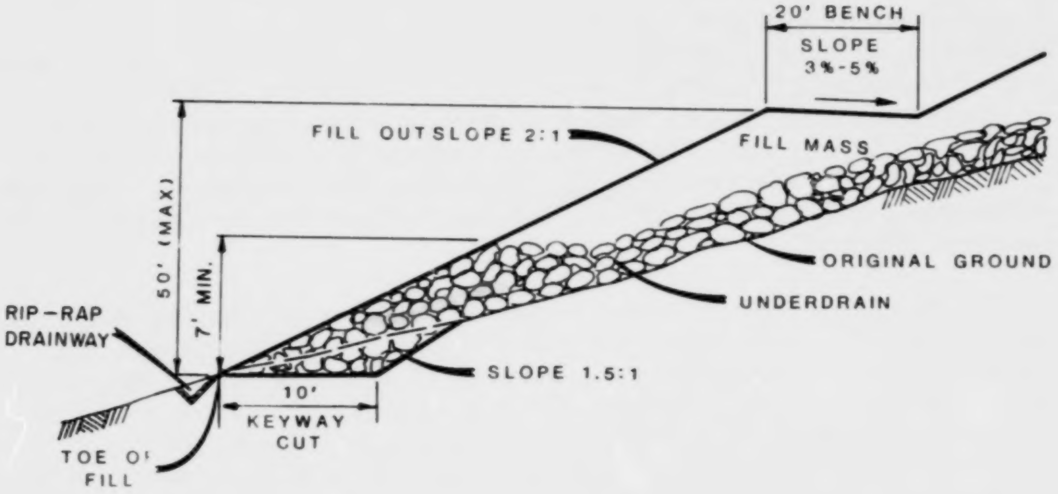

FIRST BENCH
RIP-RAP DRAIN
RIP-RAP DRAIN
SLOPE 3%-5%
SLOPE 3%-5%
FILL MASS
ORIGINAL GROUND
UNDERDRAIN
SEE TEXT

SECTION C-C'

Figure 2. Cross sections of recommended modification for head-of-hollow fills.


20' BENCH
SLOPE
3%-5%
FILL OUTSLOPE 2:1
FILL MASS
50' (MAX)
10' MIN.
ORIGINAL GROUND
UNDERDRAIN
RIP-RAP
DRAINWAY
SLOPE 1.5:1
10'
KEYWAY
CUT
TOE OF
FILL

A. TRAPEZOIDAL KEYWAY CUT


20' BENCH
SLOPE
3%-5%
FILL OUTSLOPE 2:1
FILL MASS
50' (MAX)
7' MIN.
ORIGINAL GROUND
UNDERDRAIN
RIP-RAP
DRAINWAY
SLOPE 1.5:1
10'
KEYWAY
CUT
TOE OF
FILL

B. BENCHED KEYWAY CUT

Figure 3. Cross section D-D' alternate toe stabilization designs for head-of-hollow fills.

SECTION 4

BACKGROUND INFORMATION

PHYSICAL DESCRIPTION OF THE WEST VIRGINIA STUDY REGION

Topography

Most of West Virginia can be divided into two major geographic divisions. Except for the eastern panhandle which lies in the Ridge and Valley Province, the state lies in the Appalachian Plateau. Because the Allegheny Mountain Chain is the most pronounced feature of the eastern part of the plateau, it is appropriate to consider this section individually.

The Allegheny Mountain Chain contains the highest land in the state. Peak elevations range from about 762 meters (2,500 feet) to 1,481 meters (4,860 feet) above sea level at Spruce Knob. Two topographic characteristics justify recognition of this area as a separate unit. First, the altitudes and the degree of dissection are greater here than in the plateau to the west. Secondly, the rocks of this section are mildly folded, and erosion on anticlines and synclines has produced a number of structurally controlled ridges and valleys that give the topography a pronounced lineation.

The Appalachian Plateau covers the western two-thirds of the state and includes the study region for this project. Along this division the Allegheny Front segregates the waters destined to the Atlantic Ocean and those flowing to the Gulf of Mexico. The central and western thirds of the plateau slope generally westward to the Ohio River which lies about 168 to 198 meters (550 to 650 feet) above sea level. It is a region severely dissected by dendritic water courses into a maze-like network of steep hills and narrow valleys. In places, the original plateau surface shows as the uniform top levels of the remaining ridges, although this characteristic is more prevalent in the south where the erosion has been somewhat less than that found in the northern sections. Altitudes are lowest on the western side of the plateau, where they average 366 to 427 meters (1,200 to 1,400 feet), and increase eastward as they approach the Allegheny Front. The highest point is at its eastern margin in West Virginia where peaks may rise above 1,219 meters (4,000 feet). Cut 610 meters (2,000 feet) below the plateau surface level, the New River gorge is a well known landmark in the Eastern United States.

Climatology

The variety of climatic conditions in West Virginia can only be understood in light of the diverse topographic features of the state. Located 241 kilometers (150 miles) from the ocean, West Virginia is characterized by a humid continental climate except for a marine modification on the lower panhandle. The most outstanding aspect of this type of climate is the marked contrast in temperature between summer and winter. The nature of the terrain and general topography, including the fact that the highest elevation on the plateau is along the eastern border, have important climatic effects.

Temperature variations across the state illustrate the effect of the topography. There is about as much temperature change across the state from east to west as there is in twice the distance from north to south. This variation is due to the mountains in the east where lower temperatures may be expected. Average winter minimum temperatures range from -7°C (20°F) in the mountains of the eastern and northern Panhandle, to near -1°C (30°F) in the extreme southern and southwestern corners of the state, where this study has been concentrated. Average winter maximums vary from 7°C to 10°C (45°F to 50°F), except in the mountains where they are several degrees lower. Summer brings temperatures that consistently average over 29°C (85°F) with similar geographic variations. Average minimums in summer range from 13°C (55°F) in the mountains to 18°C (65°F) elsewhere. Spring and autumn mean temperatures average between 10°C to 15°C (50°F to 59°F) and are also lower in the eastern mountains.

The last freezing day in the study area can be expected some time in mid-April. Temperatures of over 38°C (100°F) have been recorded at all stations in the state, up to 44°C (112°F) in one instance. Very low temperatures have been noted to -38°C (-37°F) at Lewisburg. During an average winter, cold waves with -18°C (0°F) or lower temperatures arrive about three times, but usually do not last more than three or four days.

Precipitation characteristics in the state are also largely a result of topographic effects. Yearly total averages, the greatest in the central section of the state, are in excess of 127 - 152 cms (50 - 60 inches). West of this section, amounts decrease to about 101 cms (40 inches) near the Ohio River. East of the central sector, precipitation decreases dramatically to about 76 cms (30 inches) with an increase to about 101 cms (40 inches) at the extreme eastern tip of the state. This trend is due to precipitation producing atmospheric currents that generally travel eastward.

As they move toward the Appalachian Mountains, they are subject to orographic lifting which causes the release of potential precipitation or intensification of present precipitation, resulting in substantial increases from west to east. Annual snowfall exhibits the same characteristics. Snow usually does not stay on the ground for extended periods, since snowstorms are followed by a thawing period; therefore, there is seldom large scale melting in the spring.

West Virginia experiences only 40 percent possible sunshine in the winter, increasing to about 60 percent in the late summer. Cloudiness is most outstanding over the mountains. The annual number of clear days averages from about 80 in the mountains to about 120 in the west.

Another factor inhibiting direct sunlight hours is the fog often prevalent in the state, especially in the valleys. The circumstances contributing to the distribution of fog in the state are diverse. Radiation type valley fogs occur when a high-pressure area is centered over the state, a common occurrence in late summer and fall. Low clouds and fog in the mountains are usually orographic in nature, caused by moist winds moving upslope. Often, due to this phenomenon, there are great differences in these conditions on opposite sides of a ridge.

Thunderstorms occur from 40 to 50 days of the year and are often accompanied by violent local winds. These storms are more common in June and July and often cause flash flooding in the narrow valleys that cut through the plateau. Precipitation accumulations over a 24 hour period have exceeded 13 centimeters (5 inches) all over the state due to these storms. In the northern part of the state, rainfall in excess of 25 centimeters (10 inches) has been recorded. Large area storms are more common during the colder half-year. These are caused by exceptionally strong specimens of the ordinary lows that affect West Virginia quite frequently. Storms of this nature produce high winds and heavy rain or snow and, in some cases, lead to flooding of river towns.

Because diverse topographic conditions exist in the study region, diverse climatic conditions exist. When compared to the state as a whole, this region shows less severe temperature patterns, but higher than average precipitation rates, since the region is on the windward side of the Appalachian range.

Geology of Soils

The topographic divisions of the state are defined by its geologic setting. The eastern panhandle, with its narrow, linear ridges and valleys, is composed of Middle and Lower Paleozoic sedimentary formations. The harder formations, principally sandstones, form the ridges, while the less resistant limestone formations form the valleys.

The Allegheny Mountain Chain is located on the eastern edge of the Appalachian Plateau. The mountain chain differs from the less elevated portions of the plateau to the west because the strata located here are more severely folded. The remainder of the plateau, in which the study region is located, is composed of these Late Paleozoic sedimentary formations, containing many coal seams.

Most of the soil types found in West Virginia can be defined as Dystrochepts (Sols Bruns Acides). The soils are warm, moist Inceptisols which exhibit weakly differentiated horizons showing alteration of parent materials. These soils are also low in bases and have no free carbonates in the subsurface horizons.

Local soil types vary considerably depending on slope and parent material. Any analysis of the implications of soil types within the study region must depend on site specific data.

Hydrology

West Virginia is drained by the Ohio and Potomac Rivers. The valley and ridge section of the state is included in the Potomac Basin, while the entire Appalachian Plateau is drained by the Ohio River.

Several tributaries of the Ohio River drain the study region, including the Big Sandy (Tug), Guyandotte, and Kanawha Rivers. Table 2 includes significant hydrologic data for these rivers. Generally, these three tributaries drain in a northwesterly direction with a dendritic pattern.

TABLE 2. HYDROLOGIC DATA-WEST VIRGINIA STUDY REGION

RIVER	LOCATION	DRAINAGE AREA (km^2)	AVERAGE DISCHARGE (m^3/s)	EXTREME DISCHARGE (m^3/s)	
				HIGH	LOW
Big Sandy	Fort Gay	10,880	121	2,530	Unknown
Guyandotte	Branchland	3,175	45	1,260	.1
Kanawha	Charleston	26,985	410	6,120	29
Ohio	Huntington	144,800	Unknown	1,850	91

(Discharge regulated by Dams and Locks)

Vegetation and Wildlife

Vegetation in West Virginia is typical of the deciduous forest biome. Oak, hickory, cherry, and maple are the prevalent hardwood species, intermingled with shortleaf, loblolly, Virginia pine and northern balsam fir. Natural understories include a variety of shrubs, forbs and grasses; farmlands support corn, small grains, cotton, tobacco and pasture.

A large number of animal species are common to the deciduous forest biome. Nuts and fruits provide food for animals such as the gray squirrel and eastern chipmunk; important mammals include the white-tailed deer, the eastern mole, black bear, gray and red fox, bobcat, raccoon, fox squirrel, New England cottontail, shortail shrew, opossum, southern flying squirrel and whitefooted mouse.

Two particular plant associations within the deciduous forest biome, the oak-hickory and maple-beech-birch associations, define wildlife species peculiar to those plant associations. Mammal populations are low in the oak-hickory portion of the biome; however, wild turkeys feed on shrubs, vines and seeds (acorns) found in this association. The association also contains a wide variety of birds. Common reptiles include copperheads, rough green snakes, rat snakes, coachwhips, and speckled king snakes.

Among the birds in the maple-beech-birch association are the solitary vireo, black throated blue warbler, blackburnian warbler, and rose breasted grosbeak. Typical reptiles in this association include the eastern garter snake, red-bellied snake, milk snake and eastern ringneck snake.

The maple-beech-birch association is located in the eastern section of the state, while the western section and the study region is dominated by oak-hickory association.

Land Use

Land use is controlled by topography. Throughout West Virginia, intensive land use is confined to the stream valleys, leaving the steep mountainsides for forests and mining. In the eastern portion of the state, the stream valleys are very narrow, so that most land is forested and ungrazed woodland. In the western part of the state, stream valleys become wider with more land devoted to cropland and pasture.

All the major urban areas in West Virginia are located in stream valleys: Huntington, Parkersburg and Wheeling are located along the

Ohio River; Charleston is located on the Kanawha. Nearly all transportation routes linking urban areas follow stream valleys. The result of this pattern is intensive strip development in these stream valleys, which are highly susceptible to flood damage.

PHYSICAL DESCRIPTION OF THE EASTERN KENTUCKY STUDY REGION

Topography

Gradually sloping in a westerly direction, the rugged Cumberland Plateau of eastern Kentucky contains approximately 27,195,000 square kilometers (10,500 square miles), or roughly one-fourth of the total land in the state. Through geological history, three principal rivers, the Cumberland, the Big Sandy, and the Kentucky, along with their large tributaries, have transformed the region into an area of long narrow valleys and steep ridges.

The parallel Pine and Cumberland Mountain Ranges in the southeast, carved from the upturned edges of hard sandstones, meet at their extreme termini to form the Middlesboro Basin. This basin contains two additional minor ranges, the Little, and Big Black Mountain Ranges. It is here that the highest mountain in the state is found, Big Black Mountain, with an elevation of approximately 1,200 meters (4,150 feet) above sea level. The general altitude of the adjacent Cumberland Plateau is approximately 600 meters (2,000 feet) above sea level and tapers westwardly reaching the Interior Low Plateaus where the elevation ranges from 76 to 122 meters (250 to 400 feet) above sea level.

Climatology

Moderate best describes Kentucky's climate. The mean annual temperature is around 16°C (60°F); average midsummer temperatures range between 24°C and 27°C (75° - 80°F). The daily average midwinter temperature is approximately 2°C to 3°C (36° - 40°F) with nights sometimes considerably colder. Temperatures in excess of 38°C (100°F) and below -18°C (0°F) occur with a frequency of about once a year, although record temperatures ranging from 46°C (114°F) to a low of -34°C (-30°F) have been recorded.

Frost-free days on the Cumberland Plateau range from 160 to 180 in the central area, and 180 to 200 on the peripheral edges. The first killing frost usually occurs between October 13th and 21st, and the last between April 18th and 23rd. Thus, the average growing season is from 174 to 189 days.

Rainfall usually averages from 97 to 102 centimeters (38 - 40 inches), with approximately 51 centimeters (20 inches) of snow falling on the plateau in the winter. The average number of rainy days is about 118 a year with the autumn months generally the driest. Rainy and snowy days are 30% - 50% more frequent in the months from December to August.

Approximately 40 to 50 thunderstorms occur per year, with less than six tornadoes per decade. Days are sunny a minimum of 52% of the year.

Winds in eastern Kentucky, as in the rest of the state, prevail from the south and southwest, and from the north and northwest in the winter.

Geology and Soils

The geologic divisions of the Cumberland Plateau are almost entirely of the Pennsylvania System, composed of interbedded sandstones, siltstones, shales, and coals. Variation in the region occurs when the ratio of these four constituents changes.

Older Mississippian formations are found in the valley floors, and the limestones characteristic of the Ordovician period contribute greatly to the fertility of the soils. However, these limestone Ordovician period deposits do not become a dominant feature until the Cumberland Plateau tapers off into the central portion of Kentucky known as the Bluegrass region, which lies adjacent to this study area.

The soils found in the valleys, the primary urban and agricultural areas, are generally flood plain soils such as Pope and Cuba while on the stream terraces and 1/2 and 2/3 of the way up the sides of the ridges, colluvial soils such as Allegheny and acidic Shelocta types are found. The upper ridge slopes are covered primarily with denser, acidic clay-shale soils, and are of a much more shallow depth than the alkaline alluvial valley soils.

Hydrology

Four major rivers drain the interior of the Cumberland Plateau: the Cumberland, the Kentucky, and Big Sandy, and the Licking (for a summary of hydrologic data, refer to Table 3). Only the Kentucky has the necessary depth to be considered a navigable inland waterway by the U. S. Water Resources Council.

The Kentucky, Big Sandy, and the Licking are part of the Ohio River Drainage Basin; the Cumberland River is incorporated into the

Tennessee-Cumberland Drainage Basin.

TABLE 3. HYDROLOGIC DATA-KENTUCKY STUDY REGION

RIVER	LOCATION	DRAINAGE AREA (km^2)	AVERAGE DISCHARGE (m^3/s)	EXTREME DISCHARGE (m^3/s) HIGH	EXTREME DISCHARGE (m^3/s) LOW
Kentucky	Heidelberg	6,881,625	163.59	2,282.35	5.64
Cumberland	Rowena	14,996,088	384.55	1,180.82	3.17
Big Sandy	Louisa	10,080,272	202.81	1,633.90	19.03
Licking	Catawba	8,546,993	175.42	1,475.32	5.75

NOTE: The flow of the Kentucky, Cumberland, and Licking is regulated by locks and dams. The Big Sandy is only partially regulated.

Groundwater aquifers are extensive in the Cumberland Plateau, and a major consolidated aquifer (composed of cavernous limestones) passes through almost 50% of the plateau. Such aquifers are capable of yielding hundreds of gallons of water per minute to individual wells.

October is the period of the lowest stream flow, and March (as a result of spring thaws) has the highest stream flow.

Land Use

Terrain limits the land use in eastern Kentucky. Most industrial, urban, and agricultural areas are contained within the stream and river valleys. Commercial coal mining (a major industry), and general farming operations utilize available slope and ridge areas. "Unused" land remains as forested areas, usually of second growth hickory and oak, some of which is utilized by a modest timbering industry. Natural gas and petroleum production are other important industries, with the Big Sandy gas fields responsible for over 90% of the state's annual production.

Major transportation facilities include Interstates 75 and 64, as well as the east-west Mountain and Daniel Boone Parkways. Due to the topography of the land, numerous north-south state highways exist throughout the Cumberland Plateau study area.

Vegetation and Wildlife

The deciduous forest biome of the Cumberland Plateau is characterized by the most varied plant and animal life in Kentucky. Dominant hardwood species include oak, hickory, maple, and poplar. Conifers such as the Virginia pine are found in isolated stands throughout the region. In the river valleys the Kentucky coffee tree, magnolia, wild plum, and crab apple also occur. Typical understory species include laurel, huckleberry, and rhododendron; wildflowers include lady slipper, trillium, violet and bluebell.

Native mammals include the eastern gray squirrel, white-tailed deer, rabbit, chipmunk, and opossum. Major mammalian predators are the mink, skunk, raccoon, and fox.

A large annual crop of acorns supplemented by beechnuts, walnuts, hickorynuts, and hazelnuts supports a varied bird life. Quail, ruffed grouse, wild turkey, and mourning dove are the principal game birds. Song birds include the bluebird, cardinal, mockingbird, and yellow warbler.

Although some isolated mountain streams contain good populations of trout, warm water fish dominate the main creeks and rivers. Species include the walleyed pike, bluegill, smallmouth bass, muskellunge, white-sucker, channel catfish, and white perch.

Three species of poisonous snakes are found: the timber rattlesnake, copperhead, and cottonmouth. Numerous harmless varieties inhabit the region.

SECTION 5

PHASE I - STATE-OF-THE-ART REVIEW

MOUNTAINTOP REMOVAL TECHNIQUE

Surface Mining

The Mountaintop Removal method of surface mining is a relatively new concept being used in the steep sloped regions of Appalachia. In 1967 the first large scale demonstration of the technique was successfully accomplished. Since then, the method has been gaining popularity as operators realize that a better return on investment can be attained through total resource recovery.

Mountaintop removal may serve as an excellent alternative to contour mining in these mountainous areas primarily because of the potential for reduced environmental impact, improved reclamation, increased land value, expanded land use potential and total resource recovery. For example, land use potential can be realized immediately following the mining and reclamation processes since all subsurface assets mineable under current technology have been extracted, thus eliminating the possibility of remining activities. Overall resource benefits must be balanced with the aesthetic appeal of this mountainous terrain.

This technique incorporates phases similar to those utilized by any surface mining operation:

- site feasibility
    - pit exploration
    - core borings
    - historical geological and mining records
- mining
    - preplanning
    - site preparation
        - silt pond construction
        - clearing and grubbing
    - drilling and blasting
    - overburden removal

  - coal removal
- reclamation
  - regrading
  - slope stability
  - seedbed preparation
  - revegetation
  - land use

Extensive premine planning for all phases is an integral part of developing an efficient mountaintop removal operation. The necessity for preplanning becomes more apparent as the physical complexity (multiple seams, slope steepness, pollution potential) increases.

Determination of site feasibility for mountaintop removal can be accomplished through direct field sampling (pit exploration, core borings), or through previously recorded data (geological and mining records). During the feasibility evaluation, consideration is given not only to coal quality but also to stripping ratio. Generally, stripping ratios of 18:1 or less are acceptable for these Appalachian coal deposits, whether the coal reserve lies in one thick seam or is divided into several thin seams.

Associated with the advent of the mountaintop removal technique was the appearance of large earthmoving equipment (i.e., $\geq$170 ton rock trucks, $\geq$ 14 cubic yard front-end loaders, $\geq$40 cubic yard draglines), and head-of-hollow (valley) fill storage areas. The large equipment tends to reduce unit operation cost and permit a greater ratio of overburden to coal, but maneuvering space is not available at mountainous contour stripping sites. Necessity for the head-of-hollow fill becomes apparent considering 1) current reclamation requirements do not permit spoil over outslopes; 2) overburden may expand by as much as one-third its original volume after excavation; and, 3) initial available bench storage space is insufficient. A detailed description of head-of-hollow fill planning, construction, and reclamation is presented later in this report.

Prior to initiating the actual mining, environmental safeguards in the form of silt basins are established. The choice of the silt pond design is generally a matter of individual company preference. Among the options are:

- gabion structures
- rock dams
- earthen dam with multiple-port standpipe
- excavated pond with spillway

Each drainage basin interrupted by the mining operation is protected by one or more of these silt structures.

Following the placement of sediment ponds, the first area to be affected by the actual mining operation is scalped of all organic materials (cleared and grubbed). If the deciduous stand is of commercial quality, this valuable resource is usually marketed prior to the initiation of site preparation. Quite often, however, the tree cover is third or fourth growth of questionable value. In this case, the timber is cut and discarded. It may be windrowed at the head of the sedimentation pond as is usually done in West Virginia and Kentucky. In some instances in Kentucky the timber is windrowed at the edges of the fills or buried with the haulback spoil.

Segregation of topsoil and temporary storage usually follow site preparation. In these steep sloped regions, topsoil is minimal (0 - 15 centimeters) and the size of the equipment usually prohibits isolation of this thin layer of strata.

The drilling and blasting techniques utilized in mountaintop removal are similar to conventional surface mining practices (i.e., area mining, contour stripping). The major considerations of this phase of mining are the following:

- drill bench level
- drill hole spacing
- drill hole size
- type of explosive
- type of detonating device
- detonation pattern
- explosive load

Physical features at the mine site which influence the choice of drilling and blasting alternatives include:

- lithology of overburden
- thickness of overburden
- fracture sizing
- noise and vibration limitations
- moisture content of overburden
- distance of overburden displacement

Final choice of drilling and blasting methods at any individual site is dependent upon site specific overburden characteristics. Prevailing conditions in southern West Virginia and eastern Kentucky coal fields are such that the following major components are typical:

- drill bench level – 7.6 to 15.2 m (25 to 50 ft.)
- drill hole spacing – 3.7 to 4.6 m (12 to 15 ft. centers)
- drill hole size – 17.2 to 22.9 cm (6 3/4 to 9 in.)
- type of explosive – ANFO (ammonium nitrate/fuel oil)
- type of detonating device – electric cap and delays, or primacord
- detonation pattern – simultaneous row, or modified chevron
- explosive load – 45.4 to 68.0 kg/hole (100 to 150 lb./hole)

When initiating surface operations on a virgin mountain, the first cut is roughly parallel to the ridge at the level of the bottom coal seam to be removed. Overburden is excavated isolating a 4.6 meter (15 foot) strip of land at the outslope as in a box-cut. This low wall barrier serves as a natural seal along the outcrop to retain surface and mine water in the operation; during reclamation, it provides support for the backfilled spoil and helps confine groundwater within the reclaimed area. Leaving the coal in this small barrier does not appreciably alter the unit profit margin, since this outcrop is generally of poor quality due to weathering. The process is only required in Kentucky.

With the advent of the mountaintop removal technique, it is now technically and economically feasible to reaffect many previously contour-mined areas for total resource recovery. Historically, these areas were mined solely for the readily available outcrop coal. Consequently, low wall barriers which are sometimes required in mountaintop removal projects, are usually not present in these reaffected sites.

Spoil storage at the onset of mining created an operational problem prior to the origination of head-of-hollow fill. From its inception, acute spoil storage problems (i.e., initial cut, excess spoil) have been reduced. After the opening of the first coal pit, overburden removal is concurrent with coal recovery.

The excavation method may vary significantly from this point, depending upon:

- number of coal seams
- presence of toxic overburden
- spoil haulage distance
- equipment type

- equipment size
- quantity of equipment
- geological formation
- final land formation

It should be apparent from the above discussion that site conditions diminish the choice of options available to the operator. In this Interim Report, specific case histories are presented to illustrate how mountaintop removal is accomplished by varying the combination of options, but in each case producing a valuable and aesthetically pleasing land form with minimal environmental degradation.

The reclamation plan for a mountaintop site is based on the ultimate land use. In addition to land use, the following items play a major role in the success of site reclamation:

- regrading - provides the final land form
- slope stability - reduces erosion and landslide potential
- seedbed preparation - ensures optimum growth conditions
- revegetation - controls erosion, improves aesthetics and provides wildlife habitat

For soil stability, a maximum of twenty degrees (20°) in Kentucky and twenty-six degrees (26°) in West Virginia is presently specified in mining regulations for all final grades. The operators are permitted a certain amount of freedom in choosing the constituents of the seedbed and vegetative mixtures. Hydroseeders are popular in these steep sloped areas, because one application will distribute nutrients (fertilizer, lime), seed, mulch and water to the prepared reclamation site. The seed mixture will include one or more species from each major category:

- nurse crop
  - rye
  - millet
- legumes
  - red clover
  - yellow clover
  - crownvetch
  - Kobe Lespedeza
  - Korean Lespedeza
  - Sericea Lespedeza
- grasses
  - Kentucky 31 fescue
  - redtop
  - weeping lovegrass

- trees
    - locust seed

Hay, straw, tree bark and wood fiber are common mulches; however, hydroseeder compatibility necessitates the use of wood fiber.

The technique — mountaintop removal — is still in its infancy and can only reach maturity through continuous evaluation of operating procedures. Realizing that the final objective is total resource recovery with minimal environmental impact, the spirit of willing cooperation must prevail between industry and government to alter ineffective procedures or regulations.

HEAD-OF-HOLLOW FILL SPOIL DISPOSAL METHOD

Surface Mining

As environmental and mining regulations became more stringent, new methods for spoil disposal were necessary if surface mining in the steep sloped regions of Appalachia was to continue. The head-of-hollow fill technique was developed as an alternative to outslope spoil disposal, thus providing an economically feasible and environmentally acceptable waste disposal method.

In southern West Virginia and eastern Kentucky, this method has been successfully employed with contour surface mining, mountaintop removal, and highway construction. This spoil disposal system is gaining popularity dispite the fact that surface mining head-of-hollow fill criteria differ drastically among states.

Although the basic head-of-hollow fill principles also apply to highway spoil disposal practices in the industry, their construction methodology and final appearance are significantly different. These variations are discussed separately by state and industry in this chapter.

West Virginia--

The key elements of hollow fill procedures (Figures 4 and 5) and current West Virginia mining and reclamation laws are as follows:

Key Elements	Regulations
• Fill Site Selection	1. Narrow "V"-shaped, steep sided hollows near ridge top

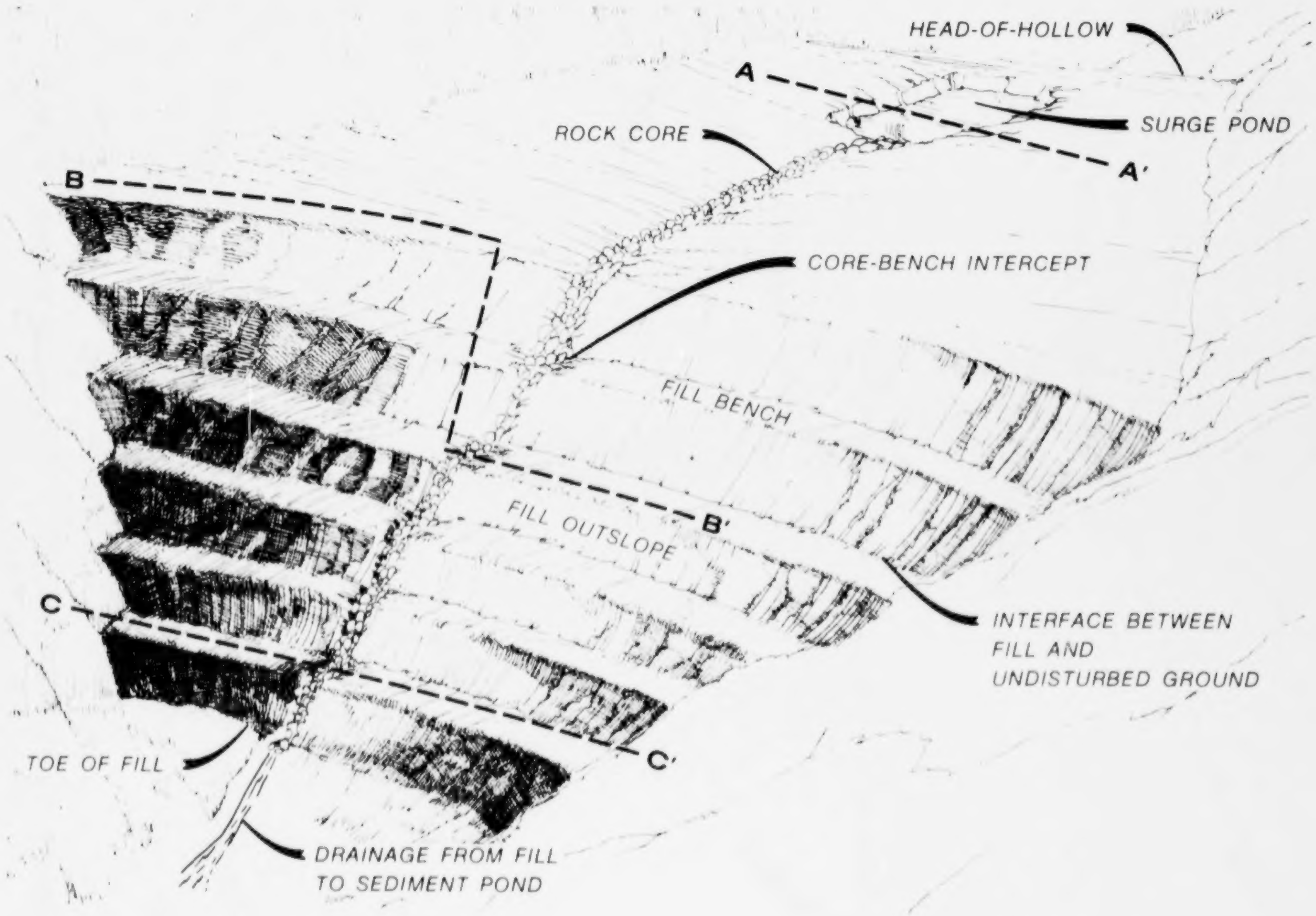

HEAD-OF-HOLLOW
A
A'
SURGE POND
ROCK CORE
B
CORE-BENCH INTERCEPT
FILL BENCH
B'
FILL OUTSLOPE
INTERFACE BETWEEN FILL AND UNDISTURBED GROUND
C
C'
TOE OF FILL
DRAINAGE FROM FILL TO SEDIMENT POND

Figure 4. West Virginia head-of-hollow fill.

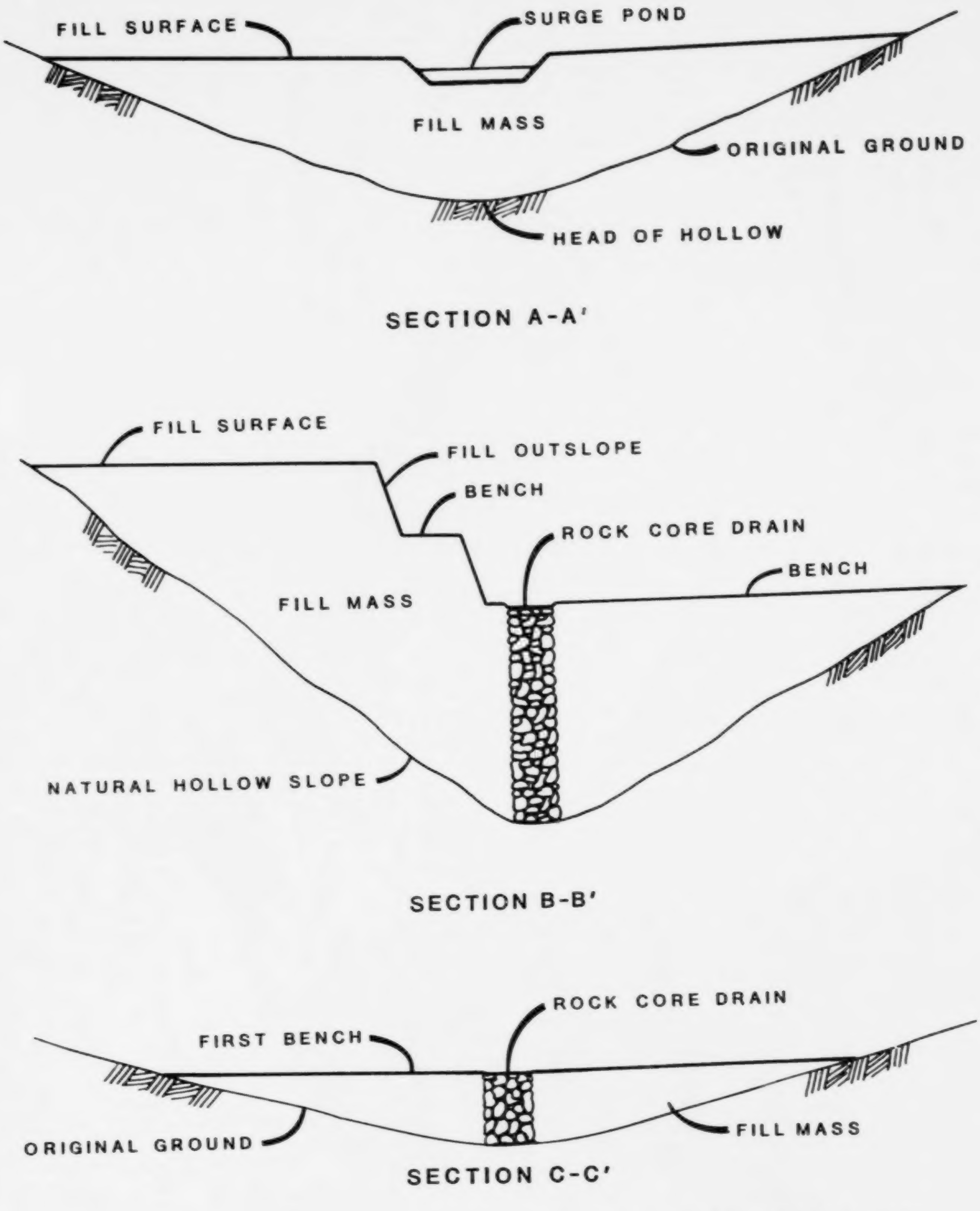

FILL SURFACE
SURGE POND
FILL MASS
ORIGINAL GROUND
HEAD OF HOLLOW
SECTION A-A'
FILL SURFACE
FILL OUTSLOPE
BENCH
ROCK CORE DRAIN
BENCH
FILL MASS
NATURAL HOLLOW SLOPE
SECTION B-B'
ROCK CORE DRAIN
FIRST BENCH
FILL MASS
ORIGINAL GROUND
SECTION C-C'

Figure 5. Cross section of typical West Virginia head-of-hollow fill.

	2. No underground mine openings or wet weather springs 3. Head-of-hollow must be completely filled
• Site Preparation	
– Sediment pond construction	1. Pond < 283 m^3 (10,000 ft.^{3}) at head of fill to discharge runoff through core 2. Second pond below toe before mining
– Erosion control	1. Vegetation windrowed at toe
– Clearing and grubbing	1. Area cleared of all organic matter
• Fill Construction	
– Core placement and dimensions	1. Progressively constructed through fill: • 4.9 m (16 ft.) wide • 90% durable rock $>$ 30.5 cm (12 in.) dimension • $\leq$ 10% rock $<$30.5 cm (12 in.) dimension
– Spoil placement	1. Hauled and placed beginning at toe in 1.2 m (4 ft.) layers parallel to finished grade and compacted before next layer
– Lift design	1. Terrace bench 6.1 m (20 ft.) wide 2. Maximum vertical height of 15.2 m (50 ft.)
– Drainage pattern	1. Outslope grade of 2:1 (26°) 2. Terrace benches sloped 3-5% toward fill and 1% toward core 3. Channel on top of core 4.2 m (8 ft.) base width × 0.6 m (2 ft.) depth

- Final fill form	1. No specifications regarding maximum height, width or maximum number of lifts
• Reclamation	
- Grading	1. Not specified
- Outslope stability	1. 2:1 grade on outslopes 2. 6.1 m (20 ft.) wide bench every 15.2 m (50 ft.) vertical height
- Seedbed preparation	1. Material suitable to support vegetation spread over entire fill excluding rock core 2. Seedbed harrowed, disced or other method 3. Application of lime, to adequate pH, depending on spoil material and plant selection 4. Fertilizer - 168 kg/Ha (150 lbs./A) ammonia nitrate; 111 kg/Ha (100 lbs./A) triple super phosphate
- Revegetation	1. Selected according to site characteristics and land use 2. Mulching - straw or hay 2240 - 4480 kg/Ha (1 - 2 T/A), wood fiber 785 - 1121 kg/Ha (700 - 1,000 lbs./A)

Local topographic and geologic conditions dictate the mine operator's construction and reclamation procedures. Even with these variations, the final product must conform to current rules, regulations and guidelines for head-of-hollow fills. In an effort to evaluate these differences in procedure, five head-of-hollow fills were investigated in southern West Virginia as part of Phase II. Detailed descriptions of fill practices at these sites are presented later in this report.

Head-of-hollow fill design is an integral part of premine planning. Although it is specific to each site, a generalized sequence of events can be presented. Factors affecting fill site selection in West Virginia are:

- topography of the hollow
- size of the hollow
- spoil haulage distance
- available equipment for spoil haulage
- drainage pattern
- availability and type of core material
- spoil material

After selection of the best available site, a sedimentation pond is constructed below the proposed toe of the head-of-hollow fill prior to any site disturbance. To ensure proper environmental safeguards for protection of downstream water quality, the following items must be considered during the design, construction, and maintenance of the silt structure:

- design
    - total drainage area
    - rainfall
    - topography
    - exposed surface area of fill
    - silt storage capacity
    - water quality regulations
    - baseline water quality
    - detention time
- types
    - initial
        windrowed vegetation
        rock check dam
        pole structure
    - final
        gabion structure
        rock dam
        earthen dam
        excavated pond
- construction
    - topography
    - available construction material
    - access
    - location
    - discharge
    - revegetation
- maintenance
    - silt storage
    - freeboard
    - bank stability

The continued necessity for the sedimentation basin after reclamation is inversely proportional to the percent of vegetative cover on the reclaimed fill site.

Upon completion of the silt structure, the area is cleared of all trees. The remainder of the organic material is grubbed. Simultaneously, diversion ditches are constructed to direct runoff through sediment ponds, thus minimizing erosion potential.

The construction phase is initiated at the proposed toe and proceeds in uniform horizontal lifts towards the head of the hollow. The first step is the placement of the central rock core. When completed, the core will provide continuous water conveyance from the head of the hollow to the sediment pond. This artificial drainage system permits surface runoff and natural water percolation to exit without saturating the fill, thereby greatly reducing erosion and landslide potential. The importance of rock constituents of the core cannot be overemphasized for its continued proper operation. If, for any reason, the core would cease to function, the environmental consequences could be more severe than outslope spoil failure which occurred due to past methods.

In accordance with West Virginia reclamation laws, all spoil placed in the fill must be transported to the lift, placed and compacted. As the lift is constructed to maximum elevation in layers of spoil 1.2 meters (4 feet) thick, the rock core must be maintained at a minimum of 1.2 meters (4 feet) above spoil deposition. The terracing appearance is created by recessing each successive lift, thus incorporating an external drainage scheme into the fill design. The resultant bench is sloped into the core, reducing the time the fill material is exposed to storm runoff.

Reclamation begins immediately following the completion of each lift. The prime benefits of concurrent reclamation are:

- reduced erosion
  - sheet erosion
  - rill erosion
- reduced core siltation
- reduced fill saturation
- increased slope stability
- prolonged sediment pond life

Fill face stability is accomplished by regrading the outslope to a maximum of twenty-six degrees (26°). During final slope formation, the seedbed is prepared by spreading a suitable top material over the face of each completed lift. The dozer's cleat depressions are left to serve as seed traps. In a one-step operation the hydroseeder applies seed, nutrients, mulch and water to the prepared seedbed. A certain degree of freedom is permitted the operator in choosing the specifics of the vegetative cover; however, by West Virginia law, the seed mixture must contain at least one species of nurse crop, legumes and grasses.

This concurrent reclamation continues through completion of spoil deposition at the fill site. The unmistakable appearance of the West Virginia head-of-hollow is obtained through the continuing process of construction and reclamation.

Kentucky--

The key elements of hollow fill procedures (Figures 6 and 7) and current Kentucky mining and reclamation laws are:

Key Elements	Regulations
• Fill Site Selection	1. Slope at toe of fill not greater than 10° 2. Must be 30.5 m (100 ft.) from confluence of water body
• Site Preparation	
– Sediment pond construction	1. Must be installed before mining
– Erosion control	1. Water emitted from pond must meet these standards: • pH – 6.0 – 9.0 • Iron – ≤ 7 mg/l • Total Alkalinity – must not exceed total acidity • Turbidity < 150 JTU's and 330 ppm
– Clearing and grubbing	1. All organic matter removed from area
• Fill Construction	
– Spoil placement and dimensions	1. "V"-shaped hollow: $\leq$ 61.0 m (200 ft.) outslope end dumped at coal seam level and pushed in layers with dozer

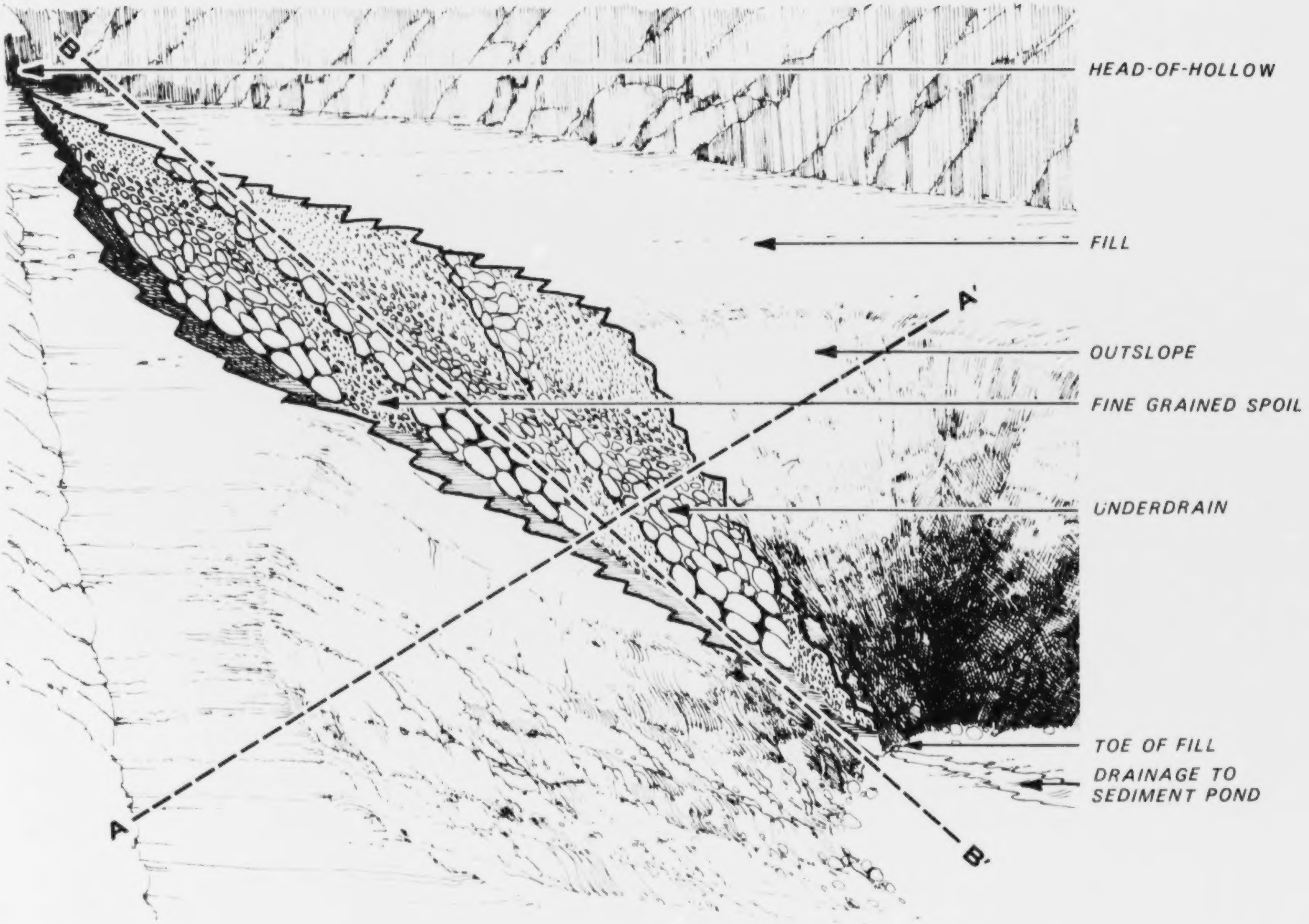
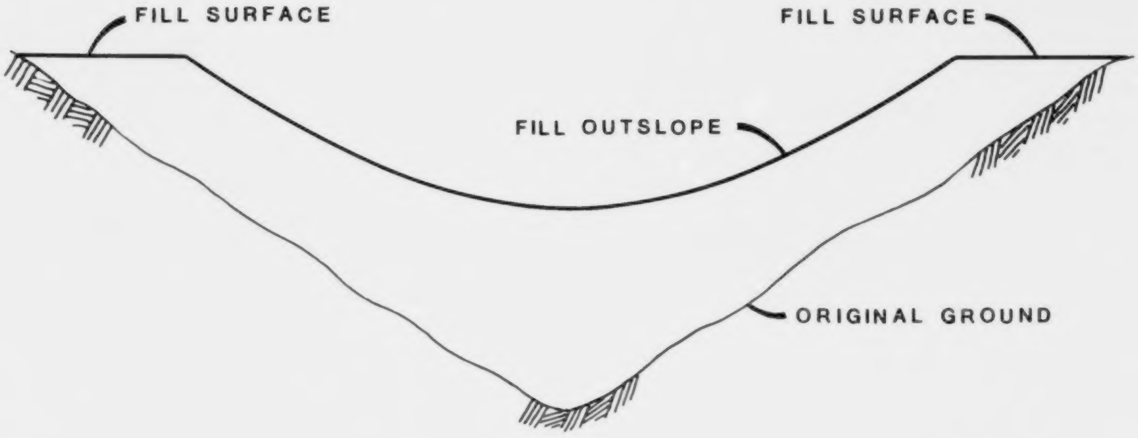
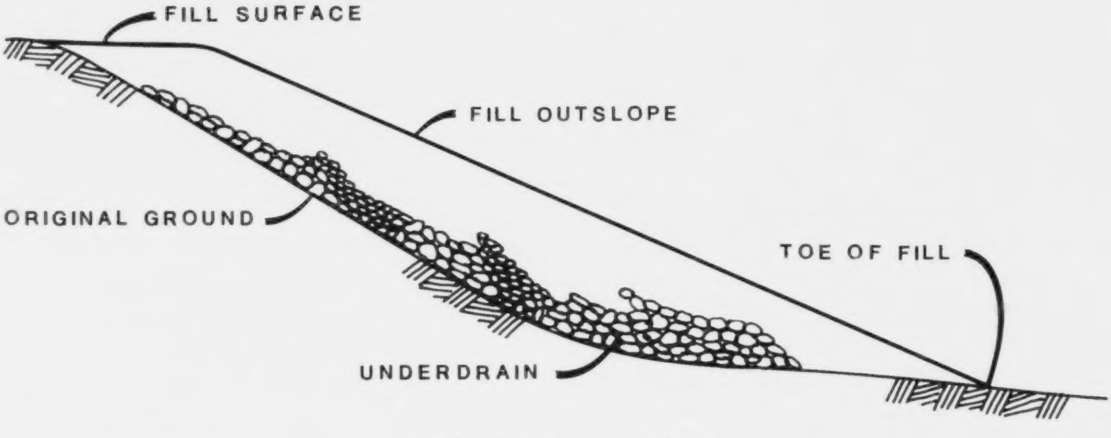

B
HEAD-OF-HOLLOW
FILL
A'
OUTSLOPE
FINE GRAINED SPOIL
UNDERDRAIN
TOE OF FILL
DRAINAGE TO
SEDIMENT POND
A
B'

Figure 6. Kentucky head-of-hollow fill.


FILL SURFACE
FILL SURFACE
FILL OUTSLOPE
ORIGINAL GROUND

SECTION A-A


FILL SURFACE
FILL OUTSLOPE
ORIGINAL GROUND
TOE OF FILL
UNDERDRAIN

SECTION B-B'

Figure 7. Cross section of typical Kentucky head-of-hollow fill.

	2. Wide "U"-shaped hollow: material hauled and placed in 1.2 m (4 ft.) lifts
– Lift design	1. Terrace bench minimum of 9.1 m (30 ft.) width at 30.5 m (100 ft.) intervals on slope
– Drainage pattern	1. Natural drainways filled with rock to provide "french drains" 2. Gradient of drainway at toe $<10^\circ$ 3. High center with grade toward hillsides from 1-2% 4. Outslope $\leq 20^\circ$
– Final fill form	1. No outslope when end dumped to exceed 61 m (200 ft.) 2. When hauled and placed, no outslope to exceed 122 m (400 ft.)
• Reclamation	
– Grading	1. All finished grades and outslopes free of protrusions so mowing equipment can traverse area
– Outslope stability	1. $\leq 20^\circ$ grade on outslope 2. 9.1 m (30 ft.) wide bench every 30.5 m (100 ft.) on slope
– Seedbed preparation	1. Ground scarified immediately before seeding 2. Lime to raise soil to pH 5.5 3. Fertilizer: • minimum of 67 kg/Ha (60 lb./A) of N • minimum of 112 kg/Ha (100 lb./A) of P_2O_5

- Revegetation	1. Perennials, annuals, legumes 2. Seed - total 62 kg/Ha (55 lb./A) 3. Mulch - rate 1680 kg/Ha (1,500 lb./A) 4. Trees - 1482 living plants/Ha (600/A) at time of bond release

Local topographic and geologic conditions influence the mine operator's choice of construction and reclamation procedures. Even with these procedural variations, the final product must conform to current Kentucky rules, regulations and guidelines for head-of-hollow fills.

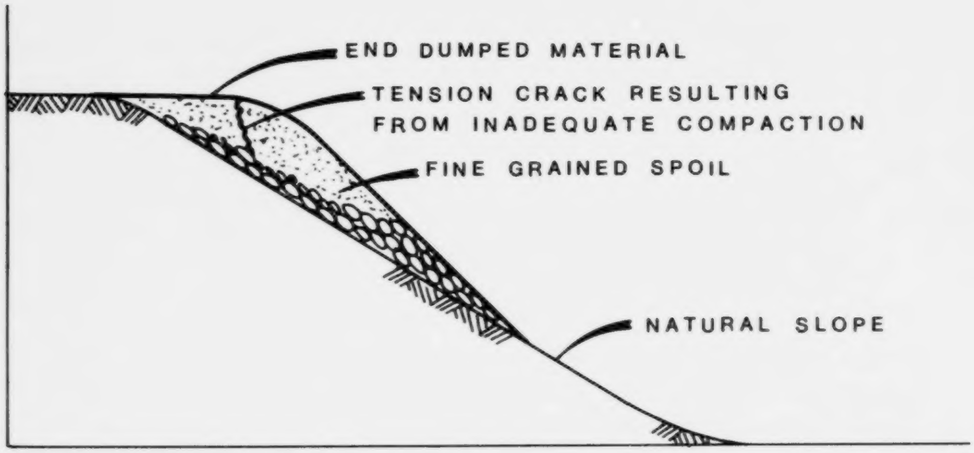
To facilitate evaluation of these differences, five head-of-hollow fills were investigated in Kentucky as part of Phase II. Detailed descriptions of fill procedures at these sites are presented in Section 6.

The methods used by Kentucky mine operators for fill site selection and site preparation are similar to those employed in West Virginia. For specifics, the reader is referred to pages 30 and 33.

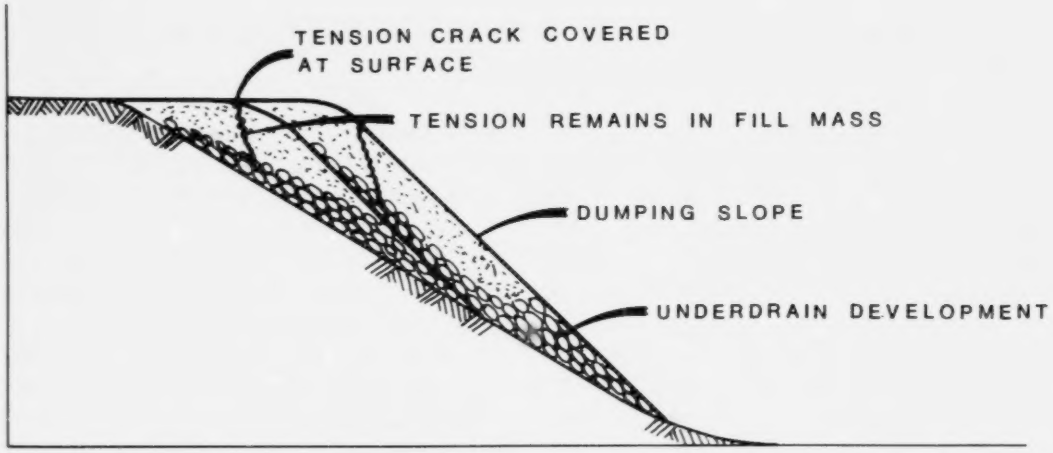
Differences appear in the state-of-the-art for Kentucky at the fill construction and reclamation phases.

Initiation of the construction phase takes place at the head of the hollow. Spoil material for "V"-shaped hollows is simply end dumped; if the hollow is "U"-shaped, spoil is hauled and placed. End dumping method of spoil placement utilizes gravity and the natural contour of the land to segregate the material by size. Theoretically, an artificial underdrain is formed (Figure 8) thus providing a system to transport water from the head of the hollow to the sediment pond. Erosion and landslide potential may be reduced because surface runoff and natural water percolation occur without saturating the fill. The fill stability depends on the proper operation of this drainage system. Ultimate success of this construction design is still in question and may vary with site specific conditions. Figure 9 illustrates a potential situation that may occur in complying with Kentucky's requirement for regrading outslope material every 48 hours.

Spoil deposition at the face provides the advancement of the fill down the hollow until the maximum design capacity is reached. At this point, construction is completed and reclamation commences. The interval between initiation of these two phases may vary from a few months to more than a year. This time lag results because subsequent spoil disposal affects the entire hollow fill, thereby precluding concurrent reclamation.

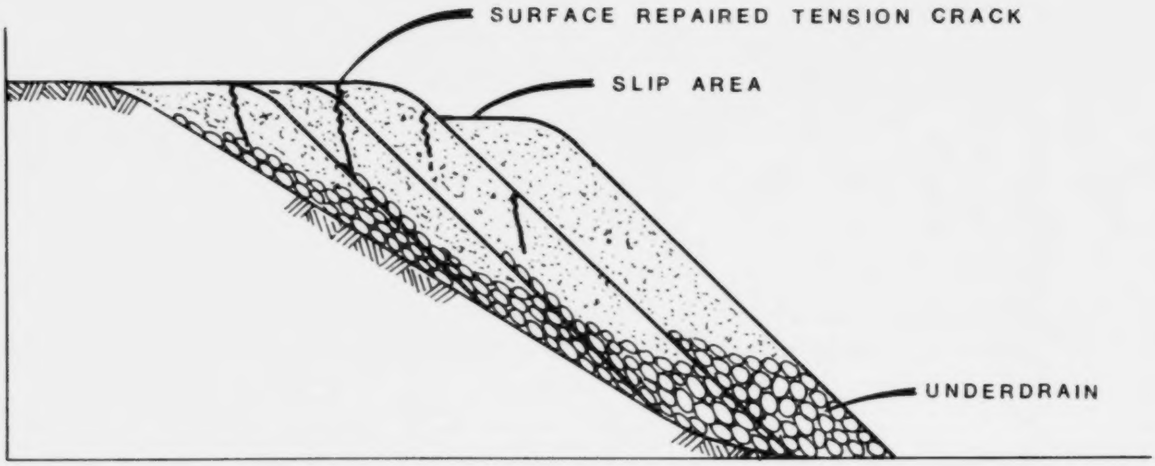

END DUMPED MATERIAL
TENSION CRACK RESULTING FROM INADEQUATE COMPACTION
FINE GRAINED SPOIL
NATURAL SLOPE

STEP 1. BEGINNING OF HEAD-OF-HOLLOW FILL

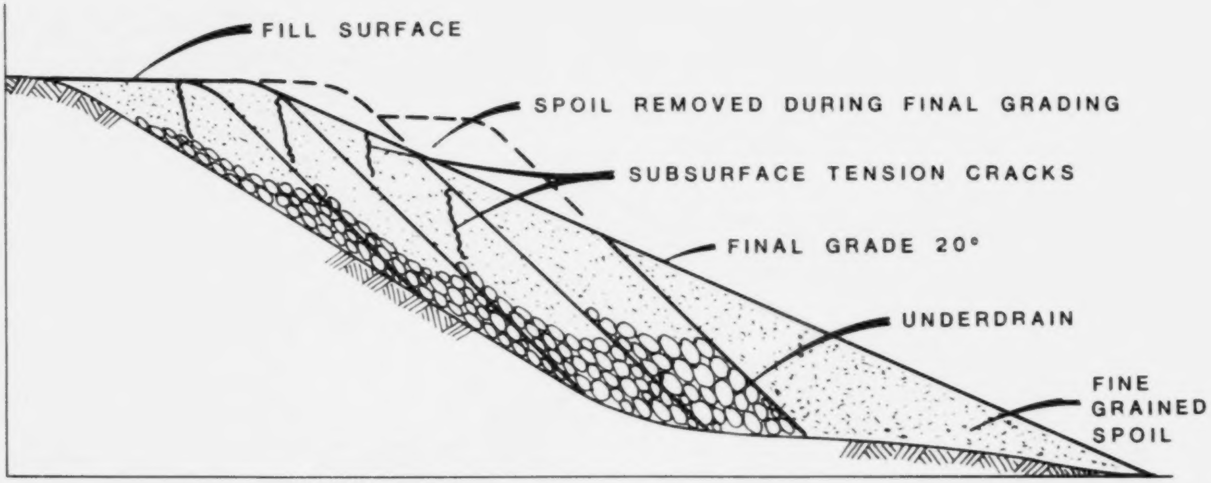

TENSION CRACK COVERED AT SURFACE
TENSION REMAINS IN FILL MASS
DUMPING SLOPE
UNDERDRAIN DEVELOPMENT

STEP 2. 48 HOURS LATER-NOT USING PUSH DOWN TECHNIQUES.

Figure 8. Sequence of Kentucky head-of-hollow fill construction not utilizing fill push down techniques.

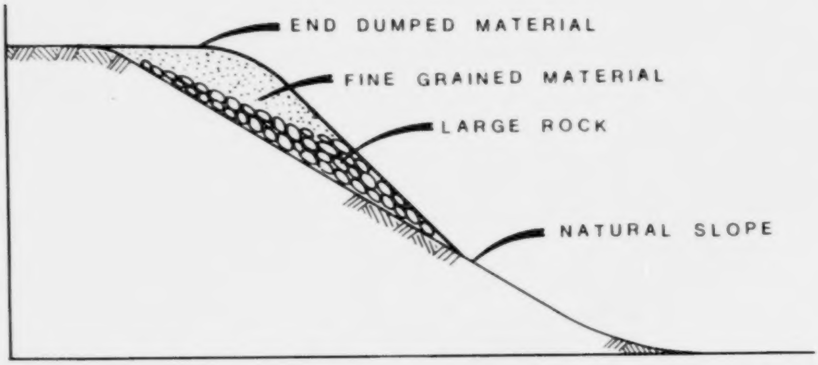

SURFACE REPAIRED TENSION CRACK
SLIP AREA
UNDERDRAIN

STEP 3. PROGRESSION OF KENTUCKY HOLLOW FILL.

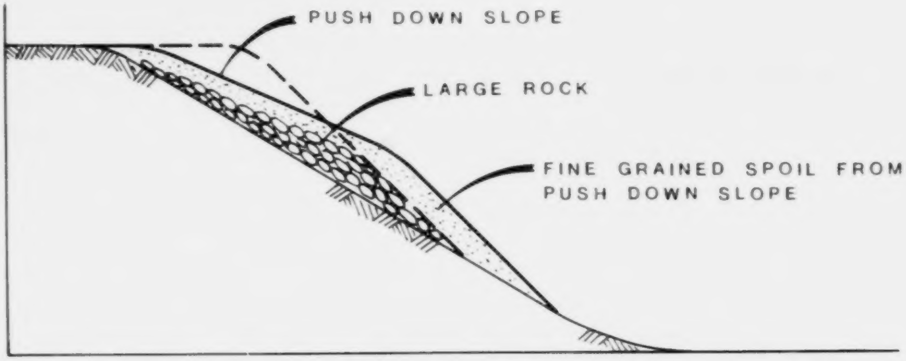

FILL SURFACE
SPOIL REMOVED DURING FINAL GRADING
SUBSURFACE TENSION CRACKS
FINAL GRADE 20°
UNDERDRAIN
FINE GRAINED SPOIL

STEP 4. FINAL GRADE (20° SLOPE) HOLLOW FILL

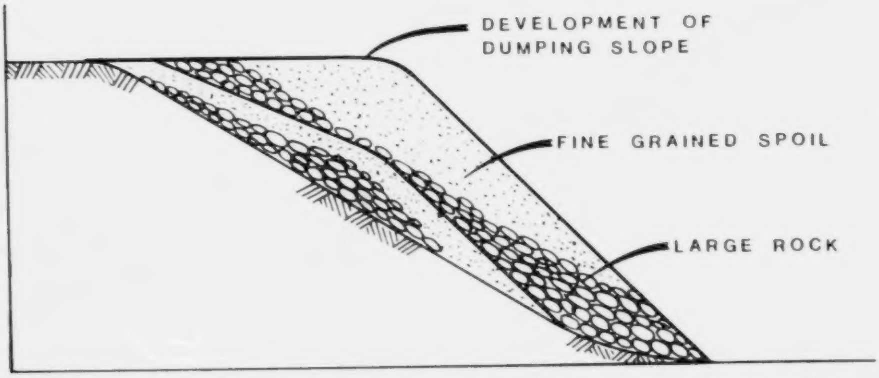
FIGURE 8. (Continued)


END DUMPED MATERIAL
FINE GRAINED MATERIAL
LARGE ROCK
NATURAL SLOPE

STEP 1. BEGINNING OF HEAD-OF-HOLLOW FILL.

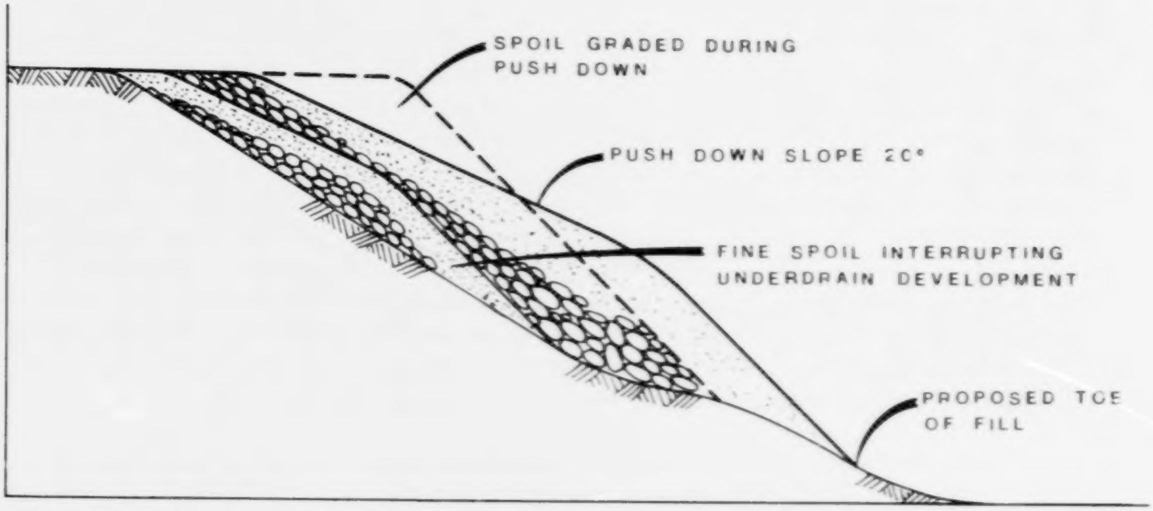

PUSH DOWN SLOPE
LARGE ROCK
FINE GRAINED SPOIL FROM PUSH DOWN SLOPE

STEP 2. 48 HOURS LATER – SPOIL IS PUSHED DOWN TO 20° SLOPE.

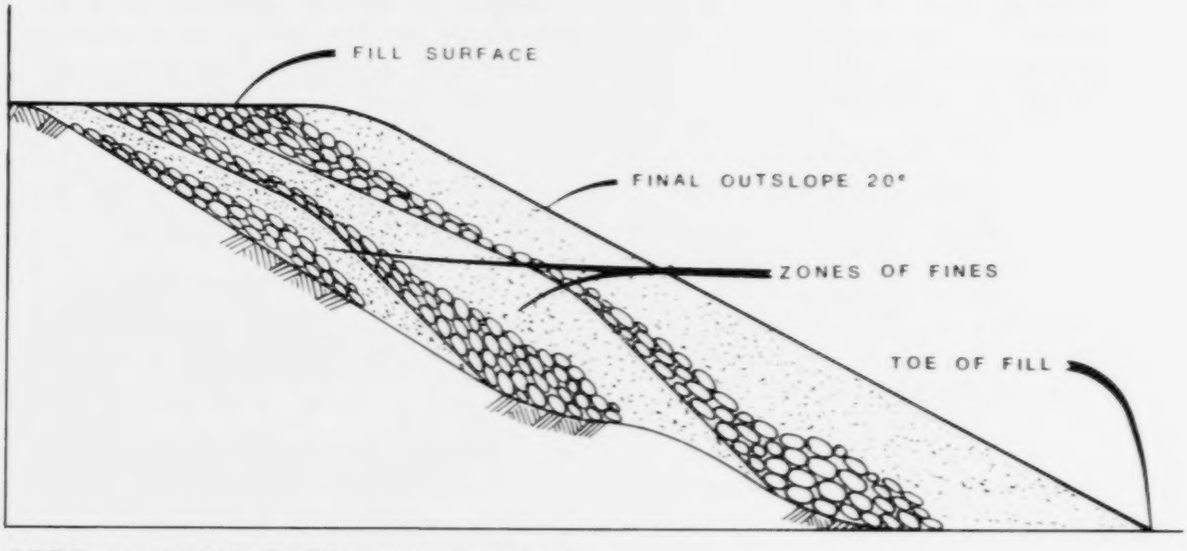

DEVELOPMENT OF DUMPING SLOPE
FINE GRAINED SPOIL
LARGE ROCK

STEP 3. PROGRESSION OF KENTUCKY HOLLOW FILL.

Figure 9. Sequence of Kentucky head-of-hollow fill construction meeting 48 hour push down requirements.


SPOIL GRADED DURING PUSH DOWN
PUSH DOWN SLOPE 20°
FINE SPOIL INTERRUPTING UNDERDRAIN DEVELOPMENT
PROPOSED TOE OF FILL

STEP 4. INTERMEDIATE PHASE OF FILL CONSTRUCTION


FILL SURFACE
FINAL OUTSLOPE 20°
ZONES OF FINES
TOE OF FILL

STEP 5. COMPLETED HOLLOW FILL.

FIGURE 9. (Continued)

Outslope stability is accomplished by regrading the fill face to a maximum of twenty degrees (20°). Seedbed preparation undertaken during final slope formation involves removing large rocks, masking potential sterile strata and spreading suitable top material over the face. The hydroseeder then broadcasts the vegetative mixture to the prepared slope. As in West Virginia, in accordance with reclamation standards, this mixture must contain a nurse crop, legumes and grasses with nutrients, mulch and water included. In addition, the outslope sections of the fill must be planted with trees. Historically, these trees have been hand planted. With the advent of hydroseeding, the necessity for manual planting has decreased considerably by adding locust seed to the vegetative mixture. The specifics of the mixture will be presented in the case studies, but the composition is determined from the major categories listed on pages 29 - 30.

Since the spoil material is at all times unprotected before hydroseeding and repeatedly exposed to the natural elements for extended periods, the importance of the sedimentation pond's proper operation and maintenance cannot be overemphasized.

Highway Industry

West Virginia--

As with the surface mine operator, the contractor building a highway in West Virginia is faced with the problem of spoil disposal. It becomes the responsibility of that contractor to dispose of all excess material encountered during the operation. In many instances the "waste" is used to form embankments, ramps, connecting roads and approaches; to construct subgrades or shoulders; or for any other purpose necessary for the completion of the project.

When, even after these applications, there is excess excavated material, the contractor must select a suitable place for its disposal.

Spoil disposal sites, as designed and constructed by the highway industry, are designated by the term "waste sites". These are generally head-of-hollow fills or valley fills where topography of the sites is similar to those used in surface mining.

Prior to actual use, waste sites must have been approved by the West Virginia Department of Highways. Requirements for approval include:

- precautions against stream pollution
- drainage precautions
- cross sections of fill showing original and proposed elevations
- computations of amount of waste

- establishment of a baseline
- written agreement between contractor and property owner for use of site
- map showing location of site
- topographic map showing:
  - proposed final grade
  - sediment basins and pollution control details
- detailed written description of:
  - types and sizes of erosion control facilities to be used
  - schedule of events and timetable
  - permanent erosion controls to prevent downstream sedimentation after waste site is no longer in use

Construction specifications for highway related valley fills differ substantially from fill sites associated with surface mines. Regulations governing all aspects of highway fill site construction are found in the state's comprehensive Standard Specifications. It is left to the contractor to design suitable drainage schemes and erosion control facilities using guidelines enumerated in the West Virginia Department of Highway's Erosion and Sedimentation Control Manual. The manual calls for sediment structures to be constructed at all locations where water is concentrated or has been collected from an area where it will pick up soil particles. There are three types of "sediment structures" that may be utilized according to site conditions:

- A sediment trap is a small excavated storage area without special inlet and outlet controls or defined side slopes and is limited to drainage areas of 4 hectares (10 acres) or less.

- A sediment pond is an excavated storage area with rock riprap placed in inlet and outlet areas with defined side slopes and by itself is limited to drainage areas of 20 hectares (50 acres) or less.

- A sediment basin consists of a dam created to impound water with or without an excavated storage area and is limited to drainage areas of 81 hectares (200 acres) or less.

Sediment structures should be constructed as close as possible to the source of sediment and outside existing watercourses to minimize the quantity of water to be treated. These silt control structures must be built prior to clearing and grubbing to realize their maximum benefits.

Temporary ridges or "berms" are suggested for use at the top of the fill site to divert and direct runoff from the surrounding area to temporary outlets where water is disposed of with minimum potential for erosion.

These berms are used at the top of newly constructed slopes to prevent excessive erosion until permanent controls are installed and/or slopes are stabilized.

When temporary berms are installed, interceptor berms transverse to centerline may be used on all grades in excess of 1% and at all locations where water is to be carried down the fill slope by temporary or permanent slope drains.

Temporary slope drains carry water accumulating on the fills down the slopes prior to installation of permanent facilities or growth of adequate ground cover on the slopes. These drains may be fiber mats; plastic sheets; stone, concrete or asphalt gutters; smooth, corrugated or half-round pipes. Although the type of drain to be used is not specified, drainage areas and size requirements for the gutters and pipes are given in Table 4.

TABLE 4. SPECIFICATIONS FOR TEMPORARY SLOPE DRAINS

DRAINAGE AREA (sq. meters)	METAL PIPE DRAINS			GUTTERS	
	SMOOTH (cm)	CORRUGATED (cm)	HALF-ROUND (cm)	DEPTH (meters)	WIDTH (meters)
0-32,000	20.3	30.5	45.7	.23	.610
32,000-48,500	25.4	38.1	53.3	.305	.610
48,500-65,000	30.5	45.7	61.0	.305	1.22
65,000-81,000	38.1	53.3	76.2	.305	1.83
81,000-97,000	45.7	61.0	91.4	.305	2.44

Anchoring drains to prevent disruption by the force of flowing water may be necessary. Surface water must be directed into the inlet end of the drain with some means provided to dissipate the water's energy. A dumped rock gutter or small sediment basin can accomplish this, as well as trap some sediment.

Before fill construction begins, the area is cleared of all trees, underbrush, stumps and other foreign matter. Waste disposal sites with a fill depth of less than 1.5 meters (5 feet) must be completely cleared and grubbed before any spoil is dumped; fill sites of greater depth need not be grubbed, but tree stumps are to be, at the most, 0.15 meters (6 inches) high. Near the toe, no stump is to extend above a point 0.31 meter (1 foot) beneath the new slope surface. Disposal of timber obtained from the clearing operation is the contractor's responsibility.

The outer 4.9 meters (16 feet) of the waste site must be compacted with heavy equipment similar to the types used to achieve specification compaction requirements on similar material in the road embankment. To control erosion, compaction at the edge of slopes and shaping and sealing the top of the waste area at the termination of each day's operations are emphasized.

Deposition of material is to begin at the lowest point of the fill. Constructed approximately parallel with the finished grade (26° or 2:1 slope), each layer is to be leveled and compacted before the next is started. When disposing of material adjacent to a stream, the outer slope must be lined with suitable rock up to the high water line to prevent erosion.

Topsoil is applied to the graded waste in accordance with criteria stated in Standard Specifications.

Seeding and mulching is a continuous operation on all waste sites during the construction process. All disturbed areas to remain exposed during critical erosion, such as diversion ditches, sediment dams, areas around sediment structures, haul road slopes, and cleared and grubbed areas are to be seeded when necessary to eliminate erosion. Temporary seeding is to be performed on a continuous basis starting when earthmoving begins in the spring and stopping when work ceases in the winter. Permanent seeding follows temporary seeding, but is permitted only during favorable seeding seasons. On slopes susceptible to critical erosion, application of mulch may be required. The contractor must assure that the seeded area will have a 75% stand of vegetation after one growing season. Any reseeding on the fill is done during regular growing seasons after re-establishing the original condition and grade.

The highway industry's criteria for waste disposal sites in West Virginia are not as stringent as regulations for the fills associated with surface mining.

Kentucky--

Generally speaking, waste excavation surpluses generated during highway construction are minimal; consequently, such materials are easily disposed of adjacent to, or uniformly incorporated into, the normal embankment construction. However, in cases where large volumes of excess excavated waste are generated and the capacity of the general right-of-way to accommodate such waste is exceeded, waste fill areas are designated and acquired.

The following considerations are usually used in assessing the suitability of an area for the relocation of excavated earth:

- Industrial potential of the site(s) in question
- Appearance of waste materials
- Drainage of area
- Approval of site

This first criteria is most important, as land deemed desirable for industrial development shall not be used for the purpose of a waste fill site.

If the Department of Commerce declares that the site under consideration is not a potential industrial area, then the Division of Design, Kentucky Department of Transportation, can proceed with plans for acquiring the waste site as a construction easement.

In cases where the site under consideration is deemed desirable for Industrial Development,

> "the designer will then prepare a preliminary plan for the proposed waste area. The Division of Design shall submit to the Department of Commerce, along with preliminary cost estimates, a request to the Department of Commerce for a recommendation as to the feasibility of the area. Cost estimates shall include:
>
> a) Right-of-way showing difference between fee simple (permanent) and construction (temporary easement);
> b) Construction (cost required to make the site available for industry such as access roads, which may not be required if taken as a construction easement), and
> c) Utility (adjustment, protection and/or relocation of existing utilities that would not be required if the site is acquired in easement."[9)]

If the second reply from the Department of Commerce indicates that the cost of developing the site for industrial use is economically feasible,

> "then the Division of Design shall obtain approval of the Commissioner of Highways via the State Highway Engineers Office prior to the finalizing of plans for permanent right-of-way (fee simple title) for the waste area in question."[10)]

Secondly, waste materials in an area open to view from a public road must be distributed so as to avoid an unsightly appearance, thus the cost of making waste earth acceptable to public view must be considered.

The third criteria considers the drainage system of the highway and surrounding area. Waste materials can at no time offer an obstruction to the planned drainage system.

Finally, the areas under consideration must have been approved from the appropriate regulatory agencies, as waste storage areas cannot be utilized without the prior approval of the Department of Natural Resources and Environmental Protection, U.S. Forest Service, U.S. Coast Guard (where applicable), and the Planning and Zoning Commissions. In addition, written copies of approval from the property owner(s), if any, as well as the owners of any utilities (of any nature) which may exist within the proposed area must be included.

> In addition, "the Engineer may require the contractor to submit drainage of proposed waste areas, showing the configuration of the original ground and the anticipated configuration of the area upon completion of the waste operation; any preparatory work such as benching; provisions for surface and subsurface drainage of the area after wasting is completed and any other information the Engineer may require before considering approval of the proposed waste area."11)

In relocating excavation materials, the same general specifications regarding erosion and seeding procedures must be followed, i.e., the application rates of agricultural limestone, fertilizer, seed and mulch must be the same as those used on similar areas within the project (see Table 5 on Erosion Control). However, upon the written request of the property owner, the variety of seed and/or plant cover may be altered. The application of this ground cover and soil conditioners also applies to the areas used for temporary haul roads during the waste relocation process.

Needless to say, top and subsoils are the principal components of the displaced waste; however, in cases where stones in excess of ¼ cubic meter (1/3 cubic yard) are found, such stones and boulders must be placed in an area (either highway or construction waste easement) that can be covered with a minimum of twelve inches of soil, thus disguising their presence.

Also in accordance with sound highway construction practices, stones of such size are at no time to be placed under a road or road shoulder, where in time, they might rise to the surface.

In general, the Kentucky highway criteria are less stringent than the surface mining regulations; however, the design criteria for highways does take into consideration the future land use of the waste disposal site.

TABLE 5. KENTUCKY HIGHWAY EROSION CONTROL

TYPE	QUALITY & QUANTITY REQUIRED
Limestone 1) Agricultural Limestone 2) 100 - Mesh Ground Limestone	1) Agricultural Limestone: Shall contain sufficient calcium and magnesium carbonates to be equivalent to no less than 80 percent calcium carbonate. 2) 100 - Mesh Ground Limestone: Shall conform to the same requirements as Agricultural Limestone. Limestone shall be applied uniformly at the rates specified in the contract; 100 - Mesh Ground Limestone shall be applied in lieu of agricultural limestone where the steepness of the slope of the soil surface makes it impractical to apply the agricultural limestone by conventional methods.
Fertilizer Only commercial fertilizers complying with the Kentucky Fertilizer Law may be used on State Highway Projects.	For Permanent Seeding: Fertilizer used and weight applied must conform with contract specifications. For Temporary Seeding: Minimum ratio of plant nutrients, nitrogen, phosphate, and soluble potash in a ratio of 10:10:10 applied at an approximate rate of 0.5 metric tons/Ha (12 pounds per 1,000 square feet).
Seed 1) Grasses: Bent Grass, Bermuda Grass, Blue Grass, Brome, Canary Grass, Fescue, Orchard Grass, Red Top, Ryegrass, Lovegrass, Oat, Rye, Timothy, Clover, and Wheat. 2) Legumes: Alfalfa, Clover, Crownvetch, Lespedeza, Sweet Clover, and Trefoil.	Seed for permanent planting must be approved by the Bureau. Typical mixtures of seed for permanent planting include: Mixture I - Mixture II 70% Kentucky 31 Fescue - 50% 15% Creeping Red Fescue - 35% 10% Red Top - 10% 5% White Dutch - 5% Note: Only crownvetch may be sown on slopes greater than 3:1, and on areas consisting of soil and broken rock mixtures, as well as on soil seams and crevices within or adjacent to rock cuts. Unless otherwise specified seed mixtures shall be sown at a minimum rate of 0.1 metric tons/Ha (2 pounds per 1,000 square feet).
Mulch 1) Straws: Baled wheat, oats, barley, or rye straw. 2) Wood Fiber: Excelsior wood fiber.	1) Straws: Free of Johnson Grass, Canada Thistle, or Nodding Thistle, and reasonably free of other foreign matter. 2) Wood Fiber: Fiber cut at a slight angle so as to allow splintering of fiber when weathering occurs. Mulch shall be applied, where applicable, at rate of approximately 1.1-4.4 metric tons/Ha (0.5 to 2 tons per acre).

SECTION 6

PHASE II - GENERAL SITE ASSESSMENT

SITE SELECTION CRITERIA

The evaluation of potential test sites was concentrated in the steep sloped areas of eastern Kentucky and southern West Virginia where mountaintop removal mining has been gaining prominence. Initial research indicated that these two regions contain a very high percentage of the mining industry's currently active mountaintop removal and head-of-hollow fill operations.

Personnel in the Reclamation Division of the West Virginia Department of Natural Resources at Charleston and the Kentucky Department for Natural Resources and Environmental Protection at Frankfort were called on to provide specific information regarding the adequacy of particular sites, the reputation of specific operators when complying with regulations, and potential willingness of the operators to cooperate in a study of this scope. Valuable information was also obtained from District Reclamation Inspectors, who are most familiar with active mine sites in their respective regions.

An in-house data retrieval system was initiated early in the project. Through previous and concurrent research projects, extensive background has been compiled on surface mining operations in Appalachia, and project personnel have developed a close rapport with many operators. These interactions have served as a basis for continued cooperation with numerous companies. A comprehensive file on mining and reclamation techniques, as well as a collection of published materials on the subjects of mountaintop removal and associated fill techniques were obtained. Utilized in this effort to update our "state-of-the-art" base of knowledge were the "computerized information system" of the Ohio State University, the West Virginia University Library, and the libraries of the Geological Sciences Department and the Engineering Department of the Pennsylvania State University, along with private sources.

Information was classified into six categories from the myriad of published information reviewed. These categories are:

- Mining: Mountaintop mining, head-of-hollow fill technology and equipment usage.
- Environmental: Benefits and detriments.
- Land Use: Current use of mined mountaintop and constructed head-of-hollow fills, and potential for future development.
- Construction and Compaction: Techniques for head-of-hollow fill construction with emphasis on problems.
- Premining Plans: Techniques applied and information developed.
- Regulations: Division of Reclamation regulations for various states, and construction specifications for Highway Department spoil disposal fill sites.

With information received from the agencies contacted, a list of potentially suitable test sites was assembled for West Virginia and Kentucky. Over 20 mine operations encompassing 60 head-of-hollow fill sites were initially considered for inclusion in the study. Each operator was contacted by phone and by mail to solicit his cooperation. For the companies responding favorably to the inquiries, preliminary field investigations were scheduled. Field tours included visits to each state's Reclamation Division, mining companies and highway departments. A "Preliminary Field Investigation" data form was developed for use in recording information gathered on these tours. Criteria recorded during the first visit concerned stage of mine development, premine engineering and planning, mine operations, and fill operations. Detailed inquiries were made about reclamation and fill site construction. Operator attitude towards the study was also an important consideration.

Mining and reclamation requirements vary between West Virginia and Kentucky, so five representative sites were chosen for each state. Operations selected showed widely divergent conditions encountered in surface mining including: 1) topography, 2) general geologic conditions (chemical/physical characteristics of overburden and fill material), 3) drainage pattern, 4) equipment employed, 5) reclamation procedures, and 6) stage of mine development. In-depth investigation was concentrated on the following variables:

- Site investigation and selection
- Engineering design
- Clearing and grubbing
- Topsoil segregation
- Blasting
- Overburden removal

- Coal extraction
- Spoil placement, terracing and compaction
- Drainage system construction
- Erosion control
- Revegetation

To accurately assess the capabilities and limitations of updated mountaintop removal and associated spoil disposal techniques and equipment, it was imperative to consolidate all information regarding these variables. By contrasting the data collected during the preliminary field investigations, operations could be selected that provided an excellent cross-sectional view of mountaintop removal methodologies now in use within the two states.

It was important that sites selected utilized good mining practices with efficient production. Adherence to state regulations was also considered in site selection.

An example of physical variations investigated were those found in design and construction of rock drain channels through hollow fills. Variables considered were materials used, relative drainage area above the fill, and presence of toxic overburden. It was very important to know how the operator actually handled these variations within the fill site. Fill configuration, lift height, compaction and construction techniques, and types of equipment were also noted as important dimensions in the study.

From all of the preliminary data, ten mountaintop removal — head-of-hollow fill operations were selected to present a valid cross-sectional view of the techniques presently being used in the coal fields of Appalachia. The ten mine sites for the study were selected and coded as follows:

West Virginia	Kentucky
BA	EA
HA	FA
MA	GA
OA	IA
PA	KA

These sites were selected, in part, because they typify the best mining and reclamation practices currently employed in their respective states. Where progress was insufficient to accurately determine mining or reclamation quality, selection was based on the reputation of the operator and his previous work at other sites.

MINE SITE BA

Physical Description

Topography
- Location – Southern West Virginia
- Terrain – Steep erosion valleys and mountains
- Elevation – 570 m (1,870 ft.) to 732 m (2,400 ft.)
- Slope – 32° on sidewalls, 8° at toe of hollow
- Area – 203 Ha (502 A)
- Vegetation – Northern Deciduous forest

Climatology
- Local storms – Intense thunderstorms average 40 days/year
- Runoff – 38 cm (15 in.)/year
- Erosion potential – Severe
- Annual precipitation – 114 cm (45 in.)
- Local temperature – See Figure 10
- Local precipitation – See Figure 11

Geology
- Strata – Above Stockton-Lewiston seam, 85% sandstone, 15% shale; below Stockton-Lewiston seam, 61 m to Winifrede, variable sandstones, clays and shales
- Age of formation – Middle Pennsylvanian
- Coal seams – Stockton-Lewiston and Winifrede

Coal quality (average)	Stockton-Lewiston	Winifrede
BTU –	13,600	14,200
Sulfur –	0.8%	0.7%
Ash –	6%	5%
Volatile matter –	36%	35%

Pedology
- Major soil association – Muskingum
- Description – Shallow to moderately deep, well drained, derived from acidic sandstones and shales
- Minor soils – None significant

Mining Technique: Mountaintop Removal

Operations
- Area – 202 Ha (500 A)
- Employees – 40
- Work schedule – Two 9-hour shifts/day for 5 days/week
- Coal series – Upper Pottsville

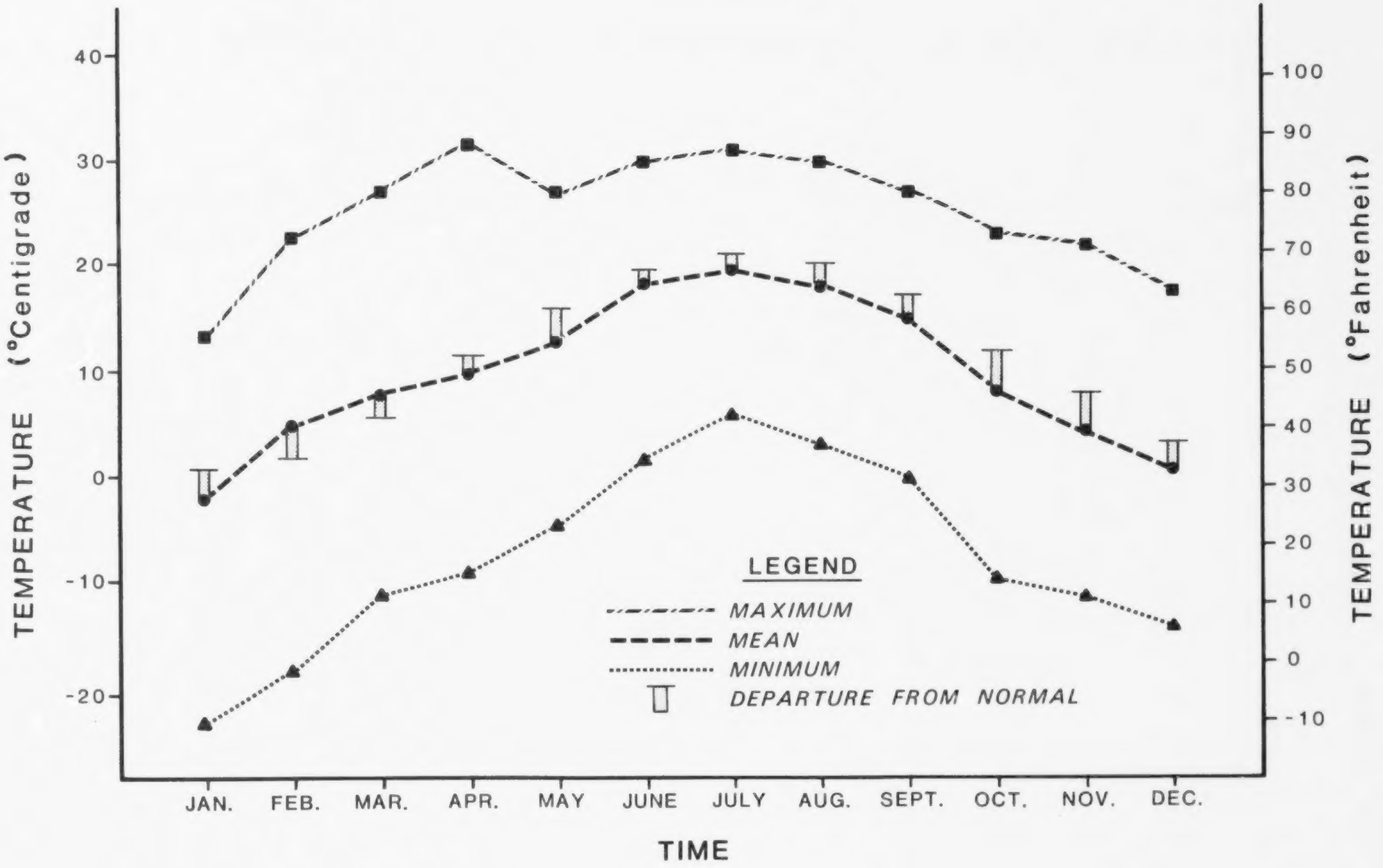


Figure 10. Temperature records in 1976 by month for mine site BA.

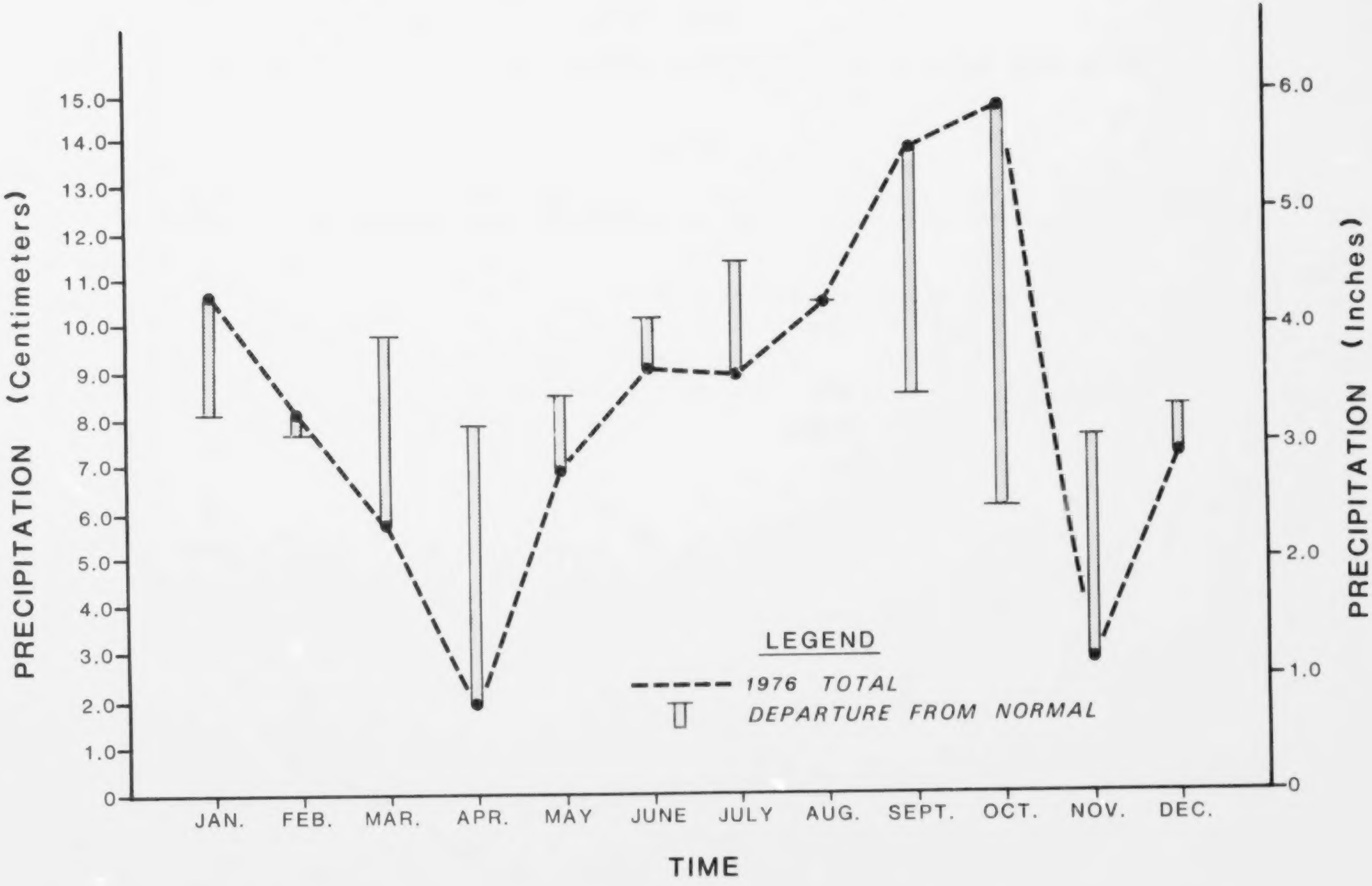


Figure 11. Total precipitation in 1976 by month for mine site BA.

Mining Techniques

- Exploration – Stratigraphic core borings
- Erosion control – Road berms, diversion ditches, and sediment ponds
- Drilling and blasting
  - Drill depth – 8-15 m (25-50 ft.)
  - Drill hole spacing – 3-4 m (10-12 ft.)
  - Drill hole size – 18 cm (7 in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and delays
  - Detonation pattern – Simultaneous row and modified
  - Explosive load – 91 kg (200 lbs.)/hole
- Overburden – Greater than 60 m (200 ft.) acid forming
- Spoil transport – Front-end loaders/trucks, hauled 1.6 km (1 mile) to fill
- Coal removal
  - Production – 1,814 metric (2,000 short) tons/day
  - Method – Front-end loader/truck
  - Haulage – Six miles to prep plant
  - Market – Utility steam

Reclamation

- Regrading – Dozer
- Revegetation
  - Area – 81 Ha (200 A)
  - Method – Hydroseeder
  - Fertilizer – 561 kg/Ha (500 lbs./A) of 10-20-10
  - Mulch – 840 kg/Ha (750 lbs./A) wood fiber
- Trees
- Intended land use – Commercial development, wildlife habitat, and pasture
- Seed mixture
  - Kentucky 31 fescue – 27 kg/Ha (25 lbs./A)
  - Redtop – 12 kg/Ha (10 lbs./A)
  - Serecia Lespedeza – 27 kg/Ha (25 lbs./A)
  - Crownvetch – 7 kg/Ha (5.5 lbs./A)
  - Black locust – 7 kg/Ha (5.5 lbs./A)

Head-of-Hollow Fill

Fill Description

- Volume – 42 million cubic m (55 million cubic yds.)
- Slope – 23° on sidewalls, 6° at toe of fill
- Spoil haulage distance – Less than 0.8 km (½ mile)

Site Preparation
- Sediment pond
  - Location – 91 m (300 ft.) from toe of fill
  - Type – Excavated; surge pool also added
  - Size –
- Erosion control – Surge pool, diversion ditches, and berms
- Clearing and grubbing
  - Type vegetation – Oak, maple, hickory, second-third growth
  - Removal method – Cut and dozered
  - Disposition – Windrowed

Fill Construction
- Underdrainage system – Fractured sandstone core
- Spoil placement – Placed by dozers and trucks adjacent to core
- Lift design – 5 lifts, graded toward center rock core
- Final fill form
  - Slope – Maximum outslope 26°
  - Area – 30.2 Ha (74.5 A)

Reclamation
- Regrading – Principal machinery: trucks and dozers
- Revegetation
  - Area –
  - Fertilizer
  - Mulch
- Seed mixture

} Same as described for the mountaintop revegetation.

Water Quality
- Periodic samples – See Table 6
- Weather condition during collection – See Table 7

MINE SITE HA

Physical Description

Topography
- Location – Southern West Virginia
- Terrain – Steep erosion valleys and mountains
- Elevation – 553 m (1,815 ft.) to 585 m (1,920 ft.)
- Slope – 26° on sidewalls, 9° at toe of hollows
- Area – 13 Ha (33 A)
- Vegetation – Second-third generation Northern Deciduous forest, principally oak, maple, beech and hemlock

TABLE 6. WATER QUALITY AT MINE SITE BA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	June	6.7	58	0	.20	10	270	550	14	60	39	–	.10	<.01	.17	<.01	–	–	640
	September	6.7	66	0	.43	<5	260	510	26	76	63	.41	.2	<.01	.40	<.01	<.03	.13	955
	November	7.3	60	0	.34	<5	180	401	3	59	40	.53	<.1	<.01	.05	<.01	<.03	<.01	500
	December	7.4	44	0	1.0	6.5	290	420	13	73	37	.47	.2	<.01	.20	<.01	<.03	.01	410
	AVERAGE	–	57	0	.49	<6.5	250	470	14	67	45	.47	<.2	<.01	.21	<.01	<.03	<.05	626
INFLUENT	September	7.9	180	0	.63	<5	330	627	8	100	124	1.5	<.1	<.01	.29	<.01	<.03	.14	865
	November	7.2	126	0	.72	<5	250	620	12	110	66	1.1	.1	<.01	.24	<.01	<.03	<.01	870
	AVERAGE	–	121	0	1.01	15	277	672	53	107	84	1.2	.3	.01	.30	.01	.03	.05	828

Note: All units mg/l except where noted.

*Average – includes results for data not shown on Table.

Months Added: Influent for December, 1976.

TABLE 7. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE BA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*FEBRUARY*	−3 (26)	11 (52)	0	3	0.13 (0.05)	70	69.47 (27.35)	32	23.3 (14.5)	21	Sunny, windy and warm
	APRIL	0 (32)	20 (68)	0	1	0.08 (0.03)	40	69.47 (27.35)	30	7.1 (4.4)	31	Sunny
	JUNE	18 (64)	30 (86)	0	1	0.15 (0.06)	90	69.88 (27.51)	52	12.2 (7.6)	19	Cloudy
	SEPTEMBER	12 (54)	23 (73)	0	4	3.6 (1.4)	90	70.36 (27.70)	40	7.4 (4.8)	14	Cloudy
	NOVEMBER	−3 (27)	12 (54)	0	2	0.53 (0.21)	0	70.10 (27.60)	36	8.5 (5.3)	18	Clear
1977	*APRIL*	12 (53)	24 (75)	0	1	0.25 (0.10)	100	70.21 (27.64)	48	18.3 (11.4)	14	Cloudy and warm

Climatology
- Local storms – Intense thunderstorms average 40 days/year
- Runoff – 38 cm (15 in.)/year
- Erosion potential – Severe
- Annual precipitation – 114 cm (45 in.)
- Local temperature – See Figure 12
- Local precipitation – See Figure 13

Geology
- Strata – 30 m (100 ft.) total above Sewell 60% shale, 35% sandstone; 15 m (50 ft.) below Sewell lies Welch seam, principally shale
- Age of formation – Lower Pennsylvanian
- Coal seams – Sewell and Welch
- Coal quality (average)

Coal quality (average)	Sewell	Welch
BTU	14,600	14,300
Sulfur	0.9%	0.5%
Ash	4%	7%
Volatile matter	22%	18%

Pedology
- Major soil association – Muskingum
- Description – Shallow to moderately deep, well drained, derived from acidic sandstones and shales
- Minor soils – None significant

Mining Technique: Mountaintop Removal

Operations
- Area – 13 Ha (33 A)
- Employees – 40
- Work schedule – Two 9-hour shifts/day for 6 days/week
- Coal series – Lower Pottsville

Equipment – See Table 8

Mining Techniques
- Exploration – Core borings
- Erosion control – Diversion ditches, berms, and sediment ponds
- Drilling and blasting
  - Drill depth – 14 m (45 ft.)
  - Drill hole spacing – 4 x 4 m (12 ft. by 12 ft.)
  - Drill hole size – 23 cm (9 in.)
  - Type explosive – ANFO
  - Type detonation – Primacord

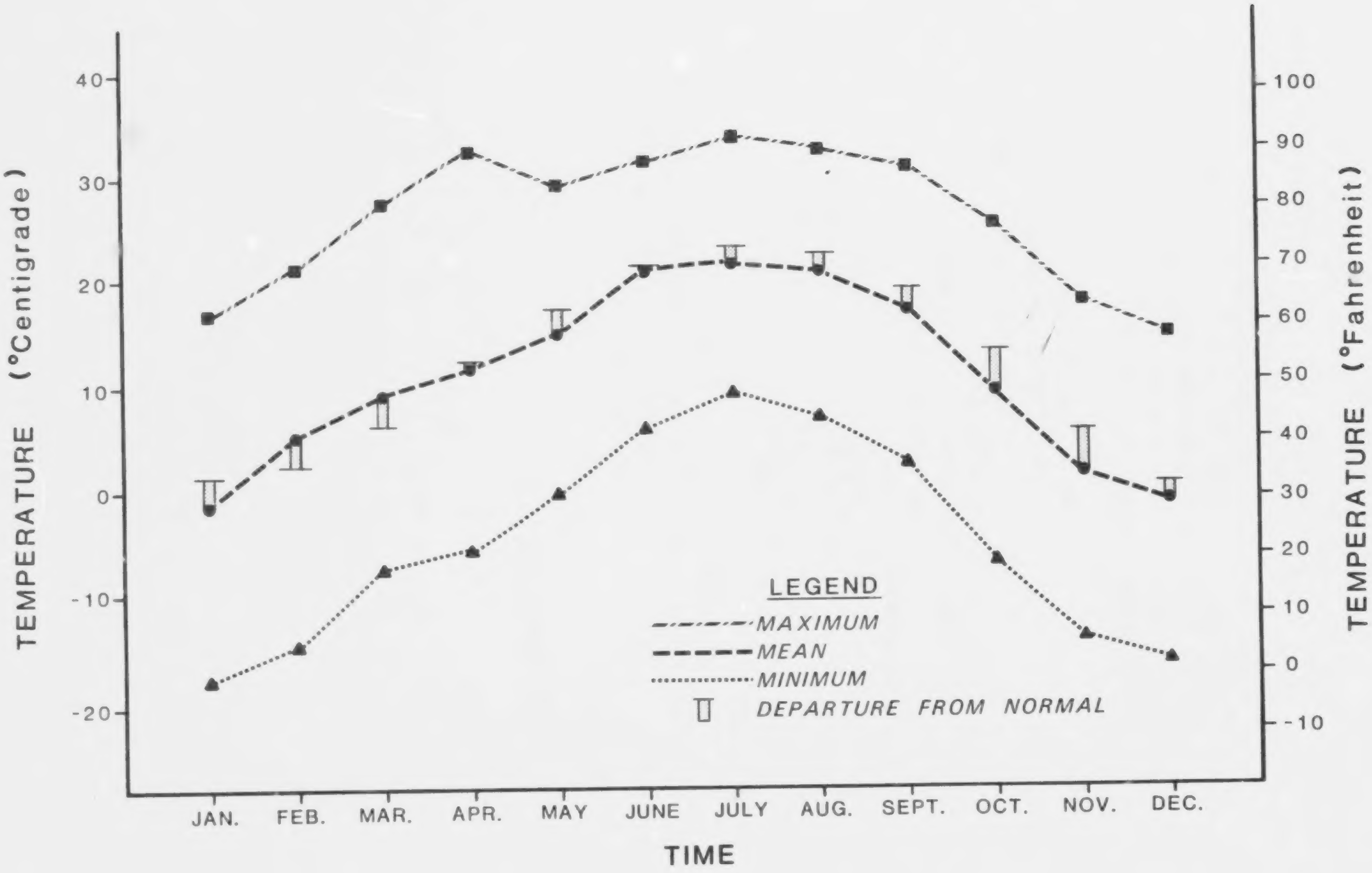


Figure 12. Temperature records in 1976 by month for mine site HA.

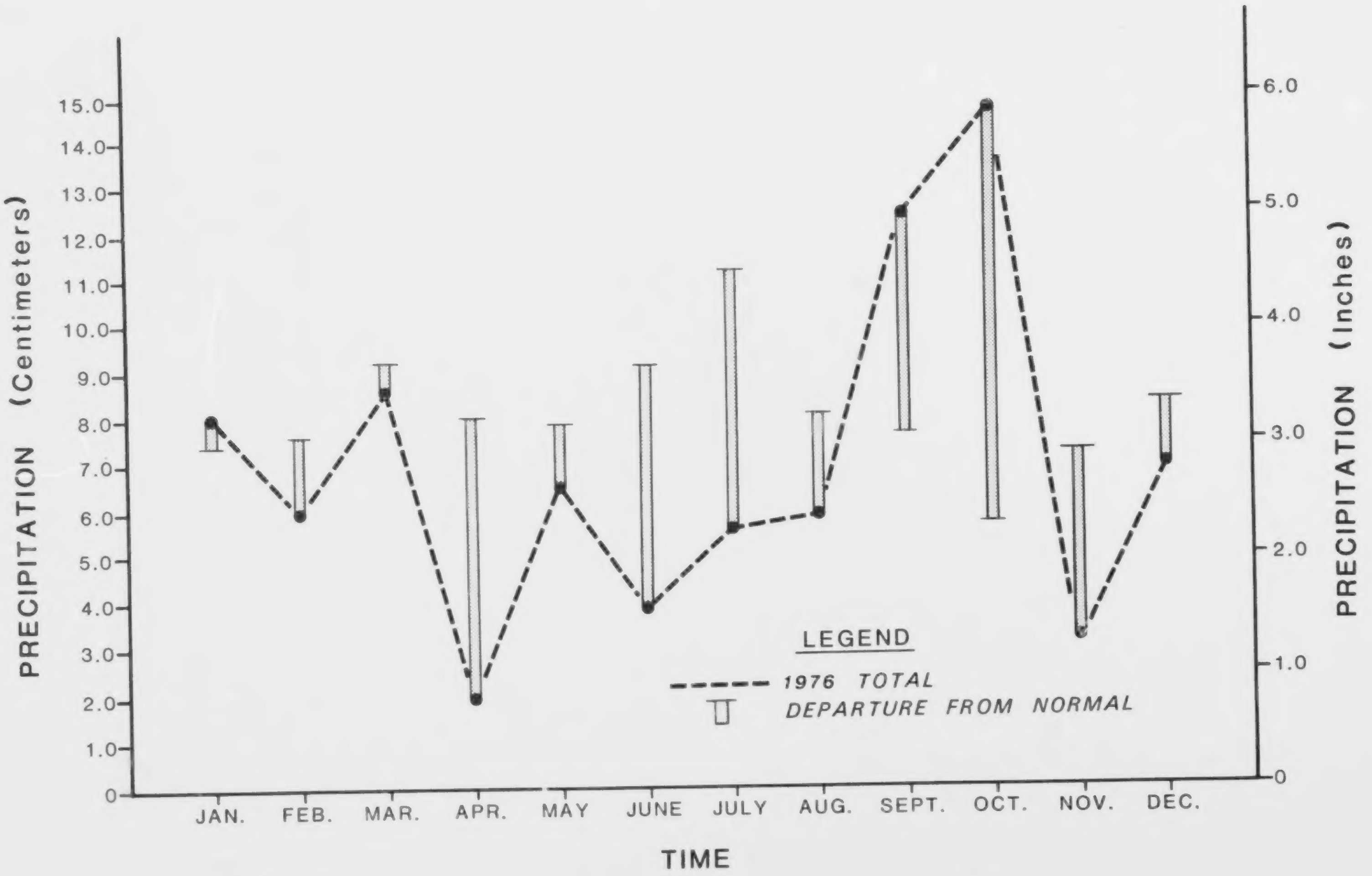


Figure 13. Total precipitation in 1976 by month for mine site HA.

TABLE 8. EQUIPMENT USED AT MINE SITE HA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Road Grader				
Cat 14	1	–	1–5	Good
Pan Scrapers				
Cat 651	2	–	1–5	Good
Euclid T524	2	–	1–5	Good
Drill				
Robbins	1	9"	1–5	Good
Drill Tech	1	6 3/4"	1–5	Good
Trucks (on-road)				
Kenmore	4	22–25 T	1–5	Good
Trucks (off-road)				
Euclid R-50	4	50 T	1–5	Good
Dozers				
D-9	5	–	1–5	Good
D-8	1	–	1–5	Good
TD-25	1	–	1–5	Good
4-D41	1	–	1–5	Good
Front-End Loaders				
Cat 988	2	5 1/2 cu. yd.	1–5	Good
Cat 992	2	10 cu. yd.	1–5	Good

Head-of-Hollow Fill

Fill Decription
- Volume – 153,000 cubic m (200,000 cu. yds.)
- Slope – 26° on sidewalls, 7° at toe
- Spoil haulage distance – 4 km (2.5 miles)

Site Preparation
- Sediment pond
    - Location – 274 m (900 ft.) from toe of fill
    - Type – Excavated
    - Size – Capacity - 8511 cubic m (6.9 ac.-ft.)
- Erosion control – Berms, diversion ditches, surge ponds

Detonation pattern – Straight row
Explosive load – 113 kg (250 lbs.)/hole

- Overburden – 46 m (150 ft.) acid-producing overburden
- Spoil transport – Pan scrapers or front-end loaders into 50 ton trucks, hauled 0.8 km (1/2 mile) to hollow fill or strip bench

- Coal removal
  - Production – 910 metric (1,000 short) tons/day
  - Method – Front-end loaders, haul trucks
  - Haulage – 6.4 km (4 miles) round trip to prep plant
  - Market – Metallurgical coal

Reclamation

- Regrading – Bulldozer
- Revegetation
  - Area – 13 Ha (33 A)
  - Method – Hydroseeder
  - Fertilizer – 560 kg/Ha (500 lbs./A) of 10-20-10
  - Mulch – 839-1121 kg/Ha (750 to 1,000 lbs./A) wood fiber
- Trees – Black Locust 1235/Ha (500/A), Autumn Olive 1235/Ha (500/A) hand planted
- Intended land use – Agriculture or woodland
- Seed mixture – Kentucky 31 fescue - 22 kg/Ha (20 lbs./A)
  – Lovegrass - 3 kg/Ha (3 lbs./A)
  – Rye - 12 kg/Ha (10 lbs./A)
  – Lespedeza - 17 kg/Ha (15 lbs./A)
- Clearing and grubbing
  - Type vegetation – Oak, hickory, maple, second-third growth
  - Removal method – Cut and dozered
  - Disposition – Windrowed at base of fill

Fill Construction

- Underdrainage system – Shale rock core
- Spoil placement – Placed adjacent to core by dozers and trucks
- Lift design – Three lifts, graded toward rock core

- Final fill form
  - Slope – Maximum outslope 26°
  - Area – 3.0 Ha (7.4 A)

Reclamation

- Regrading – Truck and dozer
- Revegetation
  - Area – 3.0 Ha (7.4 A)
  - Fertilizer
  - Mulch
- Seed mixture

Fertilizer, Mulch, Seed mixture – Same as described for the mountaintop revegetation.

Water Quality

- Periodic samples – See Table 9
- Weather condition during collection – See Table 10

MINE SITE MA

Physical Description

Topography

- Location – Southern West Virginia
- Terrain – Steep erosion valleys and mountains
- Elevation – 351 m (1,220 ft.) to 372 m (1,150 ft.) above sea level
- Slope – 23° on sidewalls, 7° on valley bottoms
- Area – 22 Ha (55 A)
- Vegetation – Mixed Mesophytic oak-hickory forest, second or third growth

Climatology

- Local storms – 40 to 50 days/year
- Runoff – 51 cm (20 in.)/year
- Erosion potential – Severe
- Annual precipitation – 122 cm (48 in.)/year
- Local temperature – See Figure 14
- Local precipitation – See Figure 15

Geology

- Strata – See Table 11
- Age of formation – Middle to Upper Pennsylvanian
- Coal seams – Pittsburg
- Coal quality (average)
  - BTU – 13,800
  - Sulfur – 2.2%
  - Ash – 7%
  - Volatile matter – 37%

Pedology

- Major soil association – Muskingum-Upshur

TABLE 9. WATER QUALITY AT MINE SITE HA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (µmhos/cm)
EFFLUENT	*FEBRUARY*	6.7	24	0	.18	5	140	350	16	36	21	.10	<.1	<.01	.02	<.01	.03	<.01	460
	APRIL	6.5	28	2	.11	5	175	390	4	70	60	.15	<.1	<.01	.04	<.01	<.03	<.01	515
	JUNE	6.8	70	0	.51	5	700	1170	3	92	49	–	.10	<.01	.07	<.01	–	–	1240
	SEPTEMBER	6.6	66	0	.57	45	130	362	32	31	24	.53	.3	<.01	.14	<.01	<.03	1.1	390
	NOVEMBER	7.2	44	0	.30	10	175	349	24	79	37	.09	.2	<.01	<.01	<.01	<.03	.07	430
	DECEMBER	7.2	46	0	.64	17	175	350	11	60	34	.33	.2	<.01	.2	<.01	<.03	.08	450
	AVERAGE	–	46.3	.3	.39	14	249	495	15	61	38	.24	.2	<.01	.08	<.01	<.03	.25	580
INFLUENT	*NOVEMBER*	7.7	132	0	–	< 5	540	1094	< 1	–	–	–	–	–	–	–	–	.01	1305
	DECEMBER	6.6	44	0	.36	2	700	1270	6	200	140	1.1	.1	<.01	.44	<.01	<.03	.03	1360
	AVERAGE	–	88	0	.36	4	620	1182	4	200	140	1.1	.1	<.01	.44	<.01	<.03	.02	1333

Note: All units mg/l except where noted.

TABLE 10. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE HA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*FEBRUARY*	0 (38)	20 (68)	0.33 (0.13)	4	Trace	70	69.55 (27.38)	58	23.5 (14.6)	28	Cloudy, rain
	APRIL	-4 (24)	19 (66)	0	2	Trace	10	69.52 (27.37)	27	7.1 (4.4)	31	Sunny
	JUNE	14 (57)	29 (84)	0	1	0.18 (0.07)	90	69.57 (27.39)	76	14.0 (8.7)	15	Cloudy
	SEPTEMBER	11 (52)	17 (63)	0.23 (0.09)	1	0.69 (0.27)	84	69.83 (27.49)	90	11.9 (7.4)	22	Cloudy
	NOVEMBER	-2 (28)	10 (50)	Trace	3	0.53 (0.21)	90	69.62 (27.41)	71	13.7 (8.5)	23	Cloudy
1977	*APRIL*	9 (49)	24 (75)	0	1	0.25 (0.10)	100	70.21 (27.64)	48	18.3 (11.4)	14	Cloudy and warm

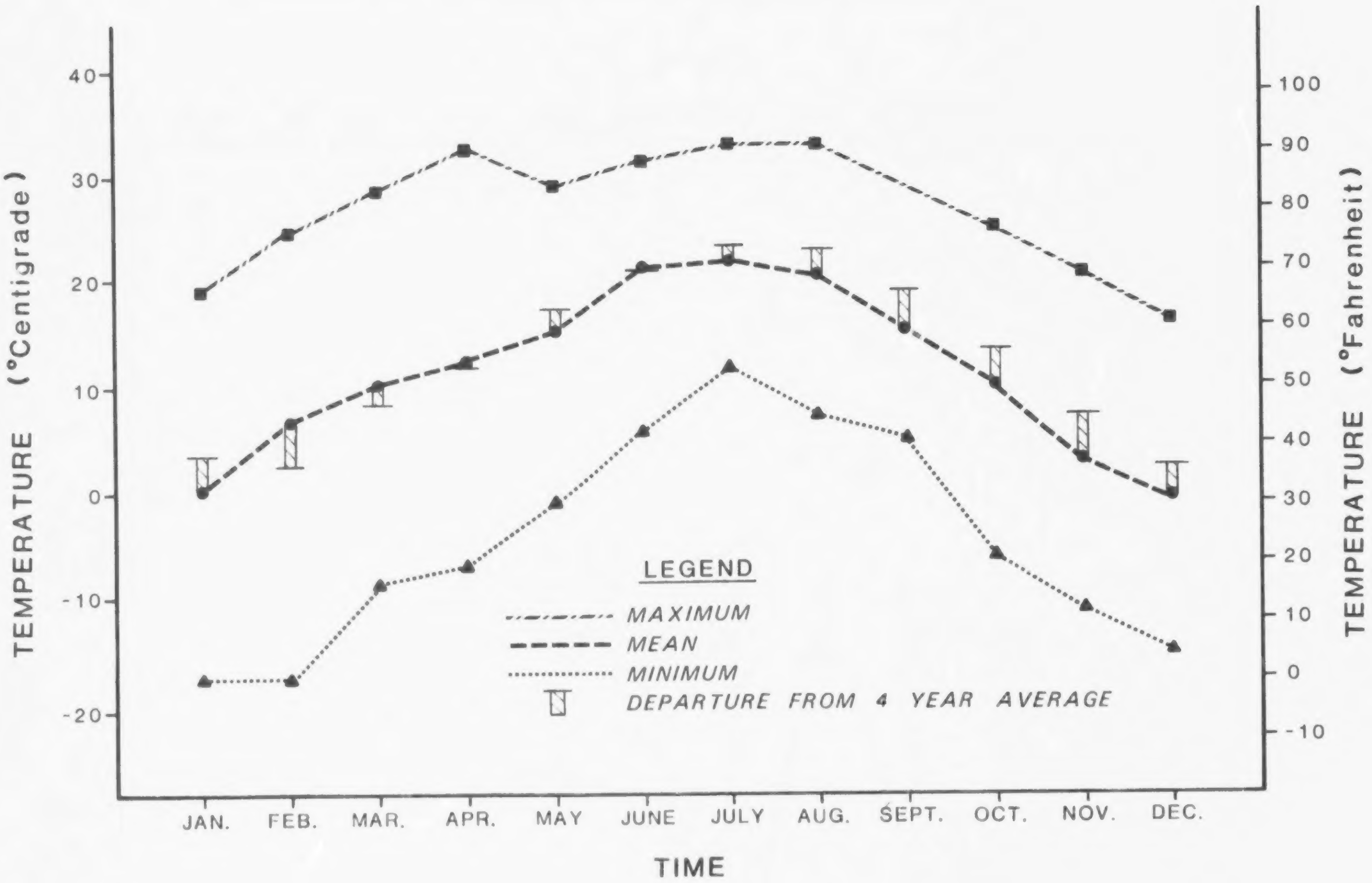


Figure 14. Temperature records in 1976 by month for mine site MA

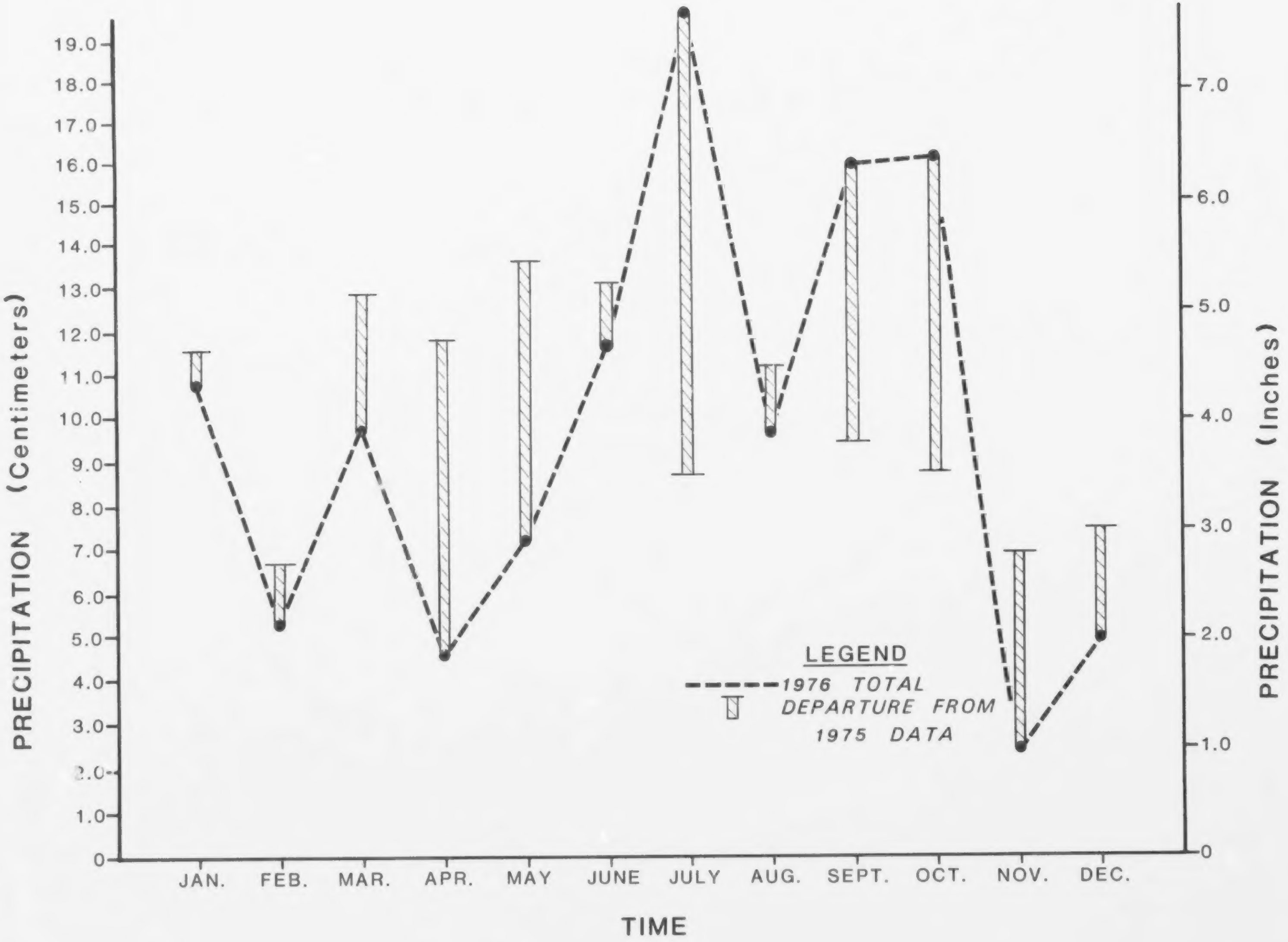


Figure 15. Total precipitation in 1976 by month for mine site MA

TABLE 11. OVERBURDEN AT MINE SITE MA

CORE CHARACTERISTICS		ROCK TYPE				TOTAL
		SANDSTONE	SOAPSTONE	SHALE	SOIL	
1	THICKNESS	10.1 (33)	4.0 (13)	7.6 (25)	0 0	21.6 (71)
	PERCENT	46.5	18.3	35.2	0	100.0
2	THICKNESS	10.4 (34)	4.9 (16)	3.1 (10)	0 0	18.3 (60)
	PERCENT	56.7	26.7	16.7	0	100.0
3	THICKNESS	14.3 (47)	1.2 (4)	2.7 (9)	0 0	18.3 (60)
	PERCENT	78.3	6.67	15.0	0	100.0
4	THICKNESS	7.9 (26)	7.3 (24)	4.9 (16)	0 0	20.1 (66)
	PERCENT	39.4	36.4	24.2	0	100.0
5	THICKNESS	14.3 (47)	3.7 (12)	1.2 (4)	.9 (3)	20.1 (66)
	PERCENT	71.2	18.2	6.06	4.55	100.0
AVG.	THICKNESS	11.4 (37.4)	4.2 (13.8)	3.9 (12.8)	.9 (3)	20.4 (67)
	PERCENT	55.8	20.6	19.1	4.48	100.0

Thickness is in meters and (feet).

- Description – Moderately deep and well drained, derived from alkaline shales, red clay subsoil
- Minor soils – None significant

Mining Technique: Mountaintop Removal

Operations
- Area – 22 Ha (55 A)
- Employees – 30
- Work schedule – Two 8-hour shifts/day for 5 days/week
- Coal series – Lower Monongahela

Equipment – See Table 12

Mining Techniques
- Exploration – Stratigraphic core borings
- Erosion control – Berms, erosion ditches, and sediment ponds
- Drilling and blasting
  - Drill depth – 12 m (40 ft.)
  - Drill hole spacing – 3 x 5 m (10 ft. by 15 ft.)
  - Drill hole size – 14 cm (15½ in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and primacord
  - Detonation pattern – Simultaneous row
  - Explosive load – 45 to 113 kg (200 to 250 lbs.)/hole
- Overburden – See Table 11
- Spoil transport – Front-end loaders or 50 ton trucks
- Coal removal
  - Production – 45,350 metric (50,000 short) tons/year
  - Method – Front-end loaders, haul trucks
  - Haulage – 6.4 km (4 miles) round trip
  - Market – Utility steam

Reclamation
- Regrading – Bulldozer
- Revegetation
  - Area – 22 Ha (55 A)
  - Method – Hydroseeder, broadcast seeder and helicopter
  - Fertilizer – 10-20-10
  - Mulch – 1680 kg/Ha (1,500 lbs./A) wood fiber
- Trees – Locust seed 44 kg/Ha (40 lbs./A)
- Intended land use – Pasture lands and meadows

- Seed mixture
  - Kentucky 31 fescue – 44 kg/Ha (40 lbs./A)
  - Birdsfoot trefoil – 44 kg/Ha (40 lbs./A)
  - Clover – 44 kg/Ha (40 lbs./A)
  - Rye – 44 kg/Ha (40 lbs./A)

TABLE 12. EQUIPMENT USED AT MINE SITE MA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loaders				
Huff 560	1	7 yd	2	Good
Huff 400	1	12½ yd	2	Good
Cat 988	1	7 yd	2	Good
Dozers				
Int. Harvester 25C	2	–	2	Good
Cat D-9	2	–	2	Good
Trucks (off-road)				
Int. Harvester 350	4	50 T	2	Good
Drill				
Davey Drill	1	5½"	2	Good
Grader				
Cat 14	1	–	2	Good

Head-of-Hollow Fill

Fill Description
- Volume – 46,600 cubic m (200,000 cubic yds.)
- Slope – 23° on sidewalls, 7° at the toe
- Spoil haulage distance – 0.8 km (0.5 mile)

Site Preparation
- Sediment pond
  - Location – 366 m (1,200 ft.) from toe of fill
  - Type – Excavated
  - Size – Surface area 2,400 m (26,000 sq. ft.)
- Erosion control – Surge pond, diversion ditches, and berms

- Clearing and grubbing
  - Type vegetation – Oak-hickory forest
  - Removal method – Cut and dozered
  - Disposition – Windrowed and buried

Fill Construction
- Underdrainage system – Fractured sandstone and shale core
- Spoil placement – Fill dumped and placed by dozer
- Lift design – Three lifts, sloped toward the rock core
- Final fill form
  - Slope – Maximum outslope 26°
  - Area – 1.7 Ha (4.3 A)

Reclamation
- Regrading – Dozers
- Revegetation
  - Area – 1.7 Ha (4.3 A)
  - Fertilizer – 10-20-10
  - Mulch – 1680 kg/Ha (1,500 lbs./A) wood fiber
- Seed mixture – Hay 4 bales/Ha (1½ bales/A)
  - Kentucky 31 fescue – 44 kg/Ha (40 lbs./A)
  - Birdsfoot trefoil – 44 kg/Ha (40 lbs./A)
  - Clover – 44 kg/Ha (40 lbs./A)
  - Rye – 44 kg/Ha (40 lbs./A)
  - Locust seed – 44 kg/Ha (40 lbs./A)

Water Quality
- Periodic samples – See Table 13
- Weather condition during collection – See Table 14

MINE SITE OA

Physical Description

Topography
- Location – West Virginia
- Terrain – Steep erosion valleys and mountains
- Elevation – 366 m (1,200 ft.) to 475 m (1,560 ft.)
- Slope – 26° on sidewalls, 11° at toe of hollow
- Area – 16 Ha (40 A)
- Vegetation – Second-third generation oak-beech forest

Climatology
- Local storms – 45 days/year

TABLE 13. WATER QUALITY AT MINE SITE
MA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	April	7.1	64	0	.40	30	83	290	30	66	20	.16	.10	<.01	.02	<.01	<.03	.02	345
	September	7.9	162	0	<.01	<5	90	292	22	60	27	.01	<.1	<.01	.37	<.01	<.03	.02	455
	November	7.5	138	0	.78	75	125	372	34	85	25	.70	.1	<.01	.18	<.01	<.03	.31	460
	December	7.3	66	0	.58	48	90	260	35	70	17	.30	.3	<.01	.54	<.01	<.03	.13	300
	January	7.3	362	0	.17	1.2	220	740	15	240	61	1.4	.1	.01	.13	.01	.03	.02	1040
	AVERAGE	-	158	0	.39	32	122	391	27	104	30	.57	.3	.01	.25	.01	.03	.01	520
INFLUENT	September	6.9	40	0	.14	5	60	173	10	31	8.5	.01	<.1	<.01	.31	<.01	<.03	<.01	250
	November	6.7	26	0	.57	<5	20	71	3	59	6.2	.02	.3	<.01	.34	<.01	<.03	<.01	120
	AVERAGE	-	33	0	.47	11.1	53	145	11	62	8.2	.02	.2	.01	.39	.01	.03	.02	203

Note: All units mg/l except where noted.

*Average - Includes results for data not shown on Table.

Months Included: Inf.: Dec. '76

TABLE 14. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE MA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	DAILY MAX.		NO DAYS	AMOUNT CM (IN)				SPEED KPH (MPH)	DIRECTION	
1976	FEBRUARY	-4 (25)	15 (59)	0	1	0.56 (0.22)	40	74.14 (29.19)	33	9.2 (5.7)	16	Partly Sunny
	APRIL	3 (37)	19 (66)	0	3	0.10 (0.04)	0	73.64 (28.99)	26	5.8 (3.6)	33	Sunny
	JUNE	17 (62)	29 (84)	0	11	0.20 (0.08)	70	73.89 (29.09)	40	8.7 (5.4)	18	Dry, Hot, Sunny
	SEPTEMBER	10 (50)	29 (84)	0	3	1.93 (0.77)	30	74.52 (29.34)	31	1.9 (1.2)	16	Partly Sunny, Warm
	NOVEMBER	-1 (30)	9 (48)	0	1	0.10 (0.04)	10	74.32 (29.26)	52	4.3 (2.7)	28	Sunny
1977	APRIL	21 (69)	29 (85)	0	15	0.20 (0.08)	90	74.24 (29.23)	33	13.8 (8.6)	18	Partially Sunny, Hot

- Runoff – 38 cm (15 in.)/year
- Erosion potential – Severe - moderate
- Annual precipitation – 114 cm (45 in.)
- Local temperature – See Figure 16
- Local precipitation – See Figure 17

Geology

- Strata – 100% sandstone
- Age of formation – Middle-Upper Pennsylvanian
- Coal seams – Lower Kittanning (No. 5 Block)
- Coal quality (average)
  - BTU – 13,500
  - Sulfur – 1%
  - Ash – 9%
  - Volatile matter – 34%

Pedology

- Major soil association – Muskingum
- Description – Moderately deep and well drained
- Minor soils – None significant

Mining Technique: Mountaintop Removal

Operations

- Area – 16 Ha (40 A)
- Employees – 14
- Work schedule – Two 8-hour shifts/day, 5 to 6 days/week
- Coal series – Lower Allegheny

Equipment – See Table 15

Mining Techniques

- Exploration – Stratigraphic core borings
- Erosion control – Berms, diversion ditches and sediment ponds
- Drilling and blasting
  - Drill depth – 9 m (30 ft.)
  - Drill hole spacing – 3 to 4 m (10 ft. to 72 ft.)
  - Drill hole size – 18 cm (7¼ in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap
  - Detonation pattern – Straight rows
  - Explosive load – 45 to 68 kg (100 to 150 lbs.)/hole
- Overburden – Acid strata of 100% sandstone
- Spoil transport – Front-end loaders and haul trucks
- Coal removal
  - Production – 9,072 metric (10,000 short) tons/year

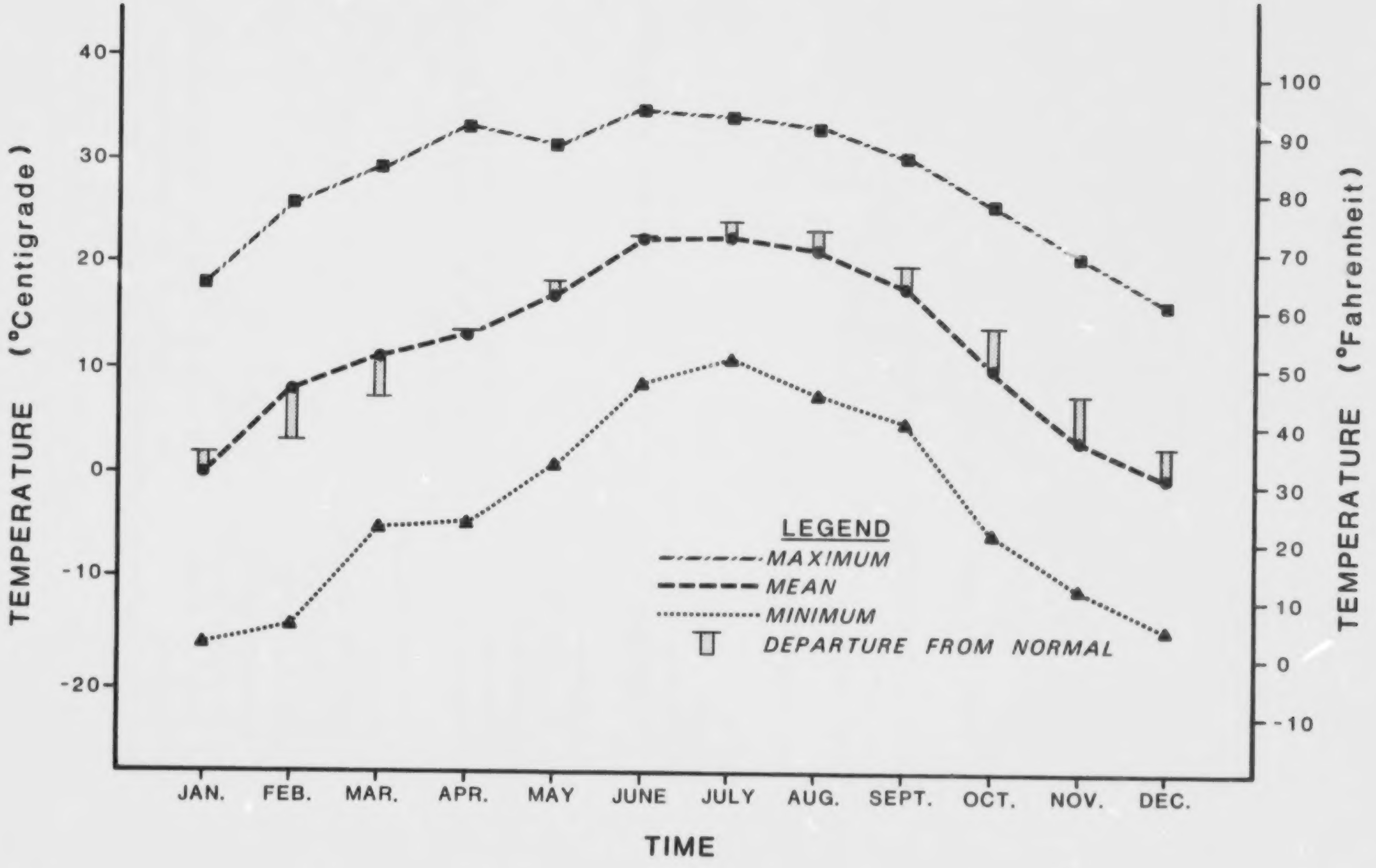


Figure 16. Temperature records in 1976 by month for mine site OA

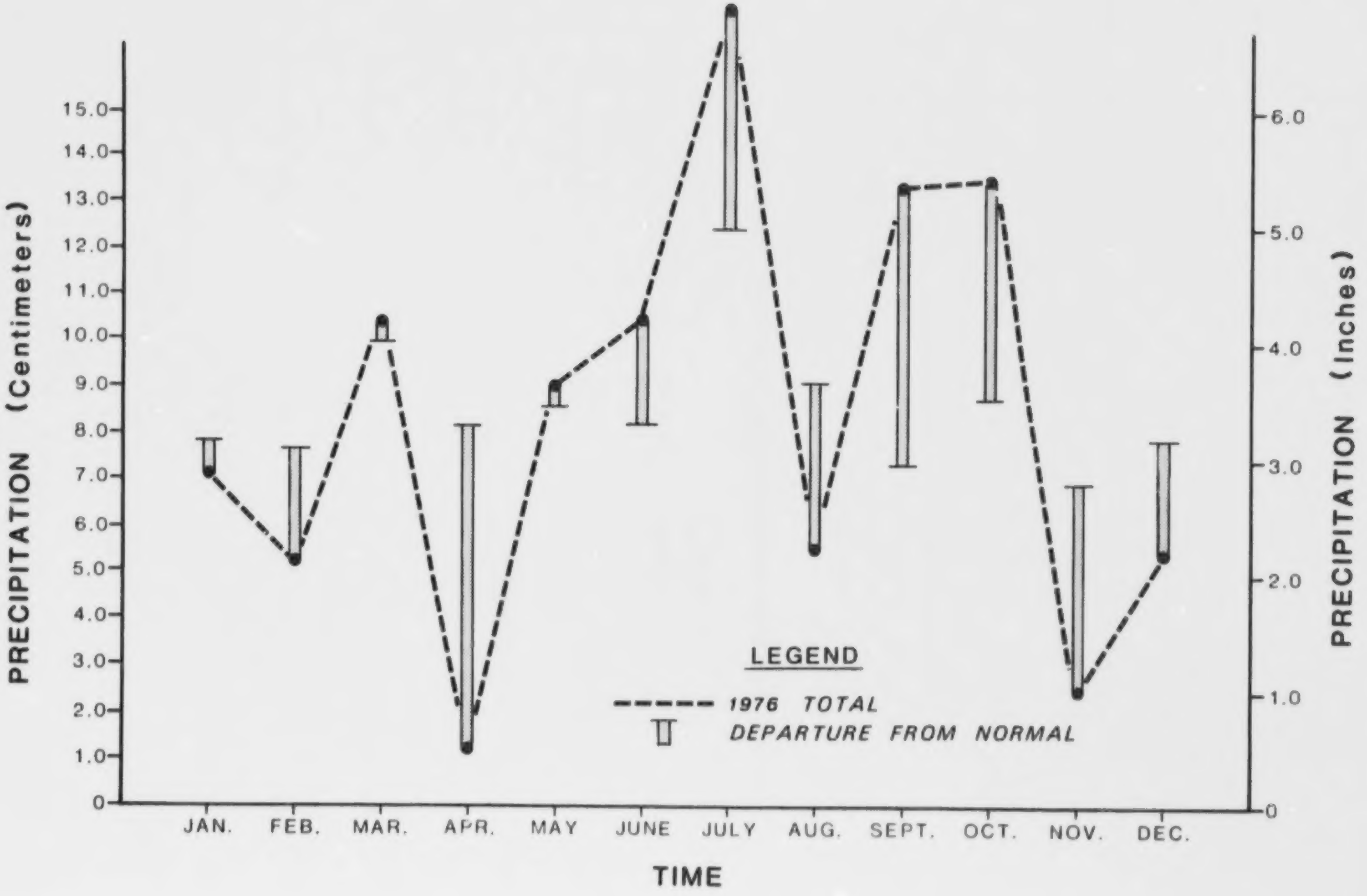


Figure 17. Total precipitation in 1976 by month for mine site OA

Method - Front-end loaders and haul trucks
Haulage - 11 km (7 miles) to prep plant
Market - Utility steam

Reclamation

- Regrading - Dozers
- Revegetation
  - Area - 16 Ha (40 A)
  - Method - Hydroseeder
  - Fertilizer - 336 kg/Ha (300 lbs./A) of 18-46-0 or 10-20-0
  - Mulch - 840 kg/Ha (750 lbs./A) wood fiber
- Trees - Virginia Pine, White Pine, Oak, Autumn Olive and European Alder
- Seed mixture - Kentucky 31 fescue - 22 kg/Ha (20 lbs./A)
  - Serecia Lespedeza - 17 kg/Ha (15 lbs./A)
  - Weeping lovegrass - 5 kg/Ha (5 lbs./A)
  - Millet - 5 kg/Ha (5 lbs./A)
  - Black locust - 5 kg/Ha (5 lbs./A)

TABLE 15. EQUIPMENT USED AT MINE SITE OA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loader				
Michigan 475 B	1	9 yd^3	-	Good
Dozers				
Cat D-9	2	Varies	-	Good
Cat D-8	1	Varies	-	Good
Trucks				
Euclid R-50	2	50 T	-	Good
Drill				
Robbins	1	7½"	-	Good
Shovel	1	5 yd^3	-	Good
Grader				
Cat 16G	1	-	-	Good

Head-of-Hollow Fill

Fill Description
- Volume - 268,000 cubic m (350,000 cubic yds.)
- Slope - 33° on sidewalls, 14° at toe of fill
- Spoil haulage distance - 0.4 km (0.25 miles)

Site Preparation
- Sediment pond
  - Location - 1.6 km (1 mile) from toe of fill
  - Type - Excavated silt structure
  - Size - 1,125 cubic m (9.1 ac.-ft.) capacity
- Erosion control - Diversion ditches, windrowed vegetation
- Clearing and grubbing
  - Type vegetation - Oak beech forest
  - Removal method - Cut and dozered
  - Disposition - Windrowed or buried

Fill Construction
- Underdrainage system - Fractural sandstone core
- Spoil placement - Haul trucks and bulldozers
- Lift design - Three lifts, overall slope 26°
- Final fill form
  - Slope - 26° overall, 5° slope west
  - Area - 0.6 Ha (1.4 A)

Reclamation
- Regrading - Dozers
- Revegetation
  - Area - 0.6 Ha (1.4 A)
  - Fertilizer
  - Mulch
- Seed mixture

} Same as described for the mountain-top revegetation.

Water Quality
- Periodic samples - See Table 16
- Weather condition during collection - See Table 17

MINE SITE PA

Physical Description

Topography
- Location - Southern West Virginia
- Terrain - Steep erosion valleys and mountains
- Elevation - 622-695 m (2,040-2,281 ft.)
- Slope - Overall average slope 24°

TABLE 16. WATER QUALITY AT MINE SITE OA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	April	6.3	16	2	.70	100	50	180	50	19	13	.04	.60	<.01	.02	<.01	<.03	.21	170
	June	6.5	42	0	.09	10	60	160	21	10	17	-	<.10	<.01	.01	<.01	-	-	230
	November	6.7	24	0	-	5	60	151	8	-	-	-	-	-	-	-	-	.09	250
	April	7.2	30	-18	.56	12	53	134	27	368	18	.09	.3	.01	.28	.01	.03	.01	170
	AVERAGE	-	28	-4	.45	32	5.6	156	27	132	16	.06	.3	.01	.1	.01	.03	.1	205
INFLUENT	November	6.9	32	0	-	35	125	317	35	-	-	-	-	-	-	-	-	.22	360
	December	7.2	40	0	.54	25	115	380	120	25	29	5.2	.2	<.01	.14	<.01	.04	.21	350
	AVERAGE	-	36	0	.54	30	120	348	78	25	29	5.2	.2	≤.01	.14	≤.01	.04	.21	355

Note: All units mg/l except where noted.

TABLE 17. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE OA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*FEBRUARY*	0 (32)	16 (61)	Trace	1	0.48 (0.19)	40	74.14 (29.19)	33	9.2 (5.7)	16	Partly sunny
	APRIL	0 (32)	19 (66)	0	4	Trace	0	73.56 (28.96)	35	8.2 (5.1)	23	Clear
	JUNE	21 (70)	33 (91)	0	1	0.03 (0.01)	70	73.89 (29.09)	40	8.7 (5.4)	18	Dry, hot, sunny
	SEPTEMBER	14 (57)	29 (84)	0	3	0.23 (0.09)	30	74.52 (29.34)	31	1.9 (1.2)	16	Partly sunny, warm
	NOVEMBER	−3 (27)	10 (50)	0	1	0.05 (0.02)	20	73.64 (28.99)	30	10.0 (6.2)	26	Partly sunny
1977	*APRIL*	12 (54)	29 (84)	0	12	0.20 (0.08)	100	73.94 (29.11)	33	5.2 (3.2)	28	Cloudy and warm

- Area – 8.0 Ha (19.8 A)
- Vegetation – Northern Deciduous, oak-maple forest

Climatology
- Local storms – 40 days/year
- Runoff – 38 cm (15 in.)/year
- Erosion potential – Severe
- Annual precipitation – 102 cm (40 in.)
- Local temperature – See Figure 18
- Local precipitation – See Figure 19

Geology
- Strata – 37 m (120 ft.) total, 82% sandstone, 8% subsoil, 7% shale, 1% fire clay
- Age of formation – Middle Pennsylvanian
- Coal seams – Lower Kittanning
- Coal quality (average)
  - BTU – 13,500
  - Sulfur – 1%
  - Ash – 9%
  - Volatile matter – 34%

Pedology
- Major soil association – Muskingum
- Description – Shallow to moderately deep, well drained, derived from acidic sandstone and shale
- Minor soils – None significant

Mining Techniques: Mountaintop Removal

Operations
- Area – 8 Ha (20 A)
- Employees – 22
- Work schedule – Two 10-hour shifts/day for 5 days/week
- Coal series – Lower Allegheny

Equipment – See Table 18

Mining Techniques
- Exploration – Stratigraphic core borings
- Erosion control – Box cuts, sediment pond, berms and diversion ditches
- Drilling and blasting
  - Drill depth – 8 m (25 ft.)
  - Drill hole spacing – 4 m (12 ft.) centers
  - Drill hole size – 23 cm (9 in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and delays

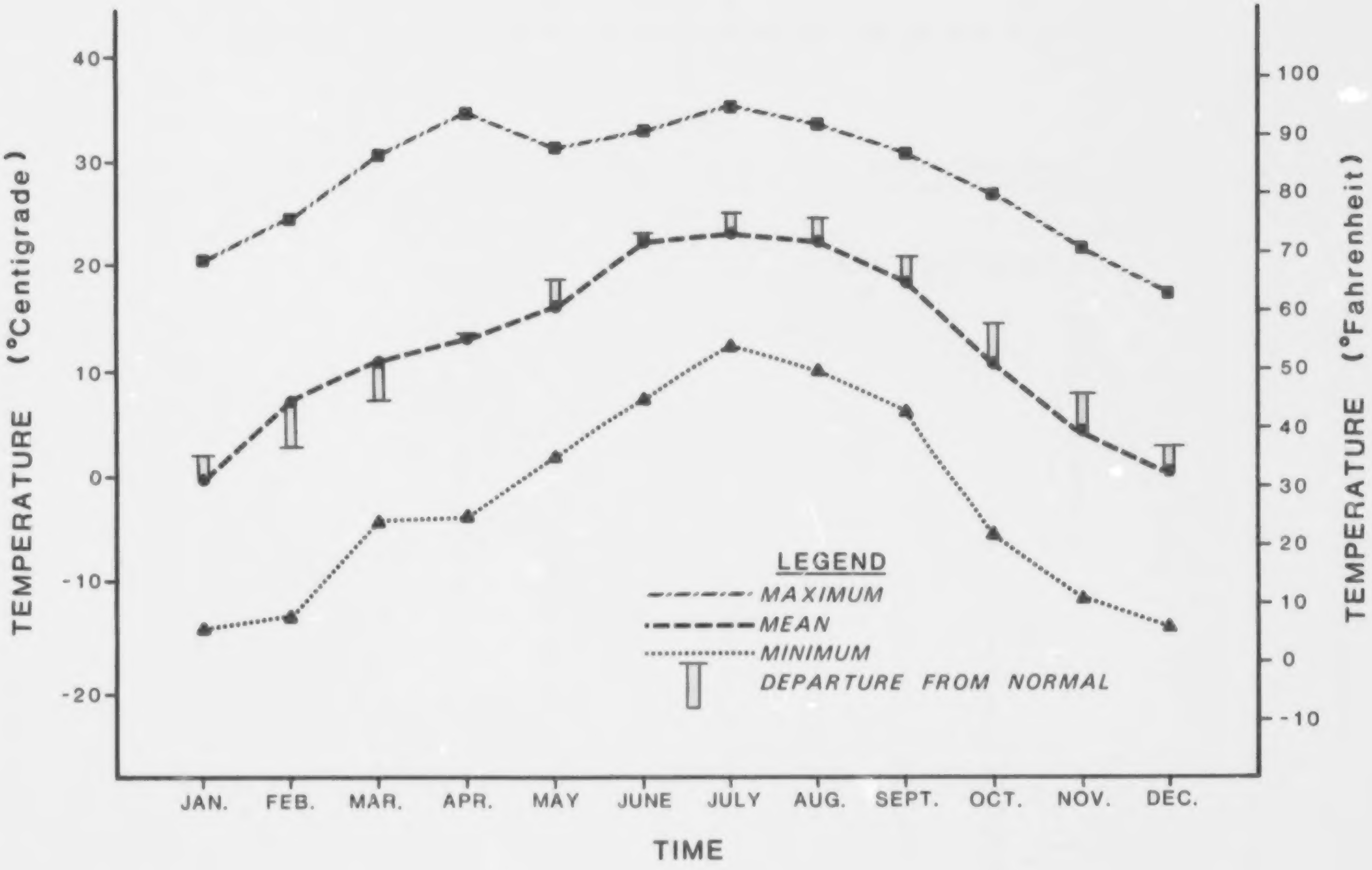


Figure 18. Temperature records in 1976 by month for mine site PA

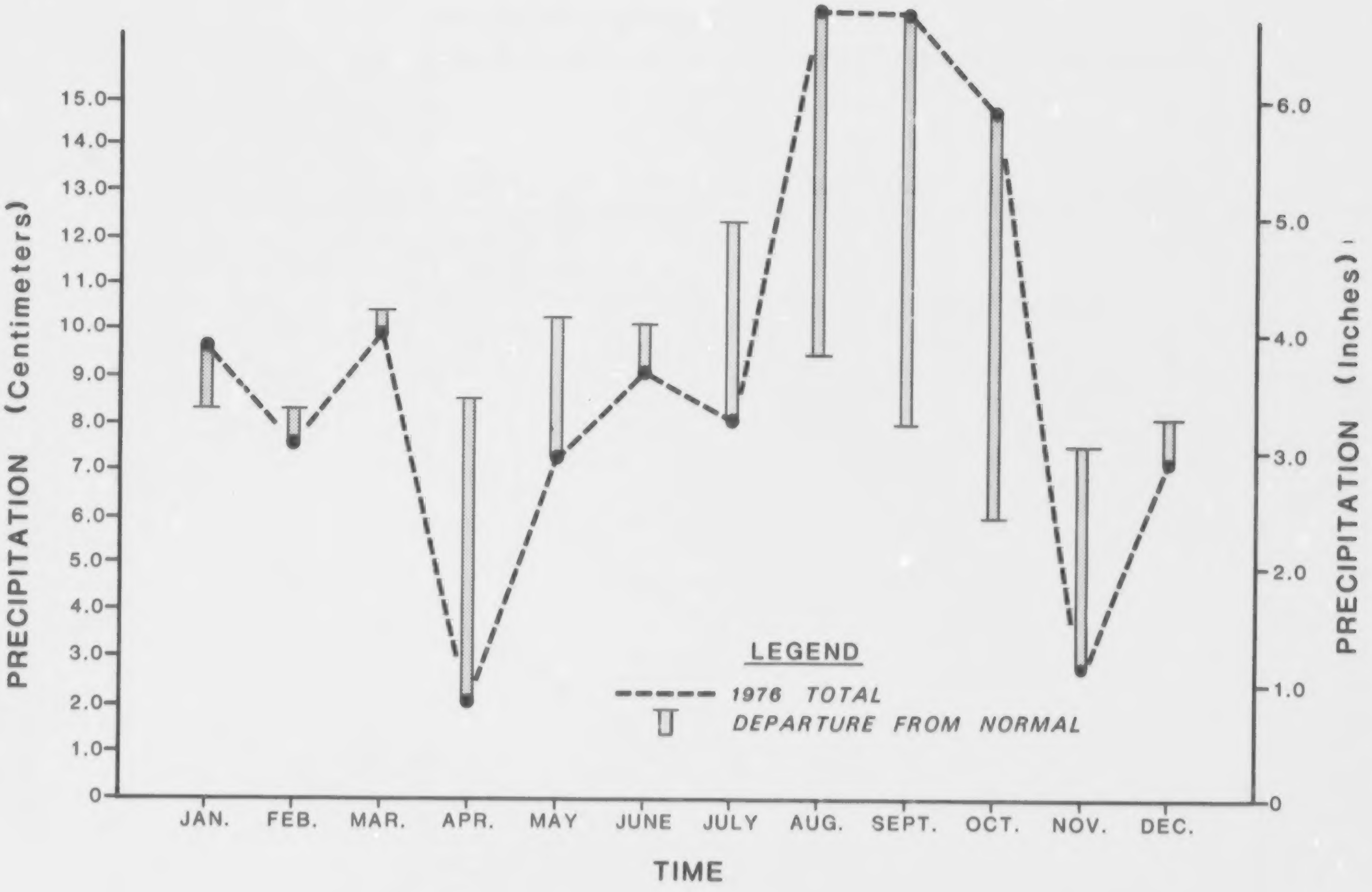


Figure 19. Total precipitation in 1976 by month for mine site PA

    - Detonation pattern – Straight rows
    - Explosive load – 68 kg (150 lbs.)/hole
- Overburden – 30 m (100 ft.) acid-producing sandstone, some shale
- Spoil transport – Front-end loaders/trucks
- Coal removal
    - Production – 181,440 metric (200,000 short) tons/year
    - Method – Front-end loaders/trucks
    - Haulage – 6.4 km (4 miles) to prep plant
    - Market – Utility steam

Reclamation

- Regrading – Bulldozers used, cleat tracks used as seed traps
- Revegetation
    - Area – 8 Ha (20 A)
    - Method – Hydroseeder and aerial seeding
    - Fertilizer – 561 kg/Ha (500 lbs./A) of 10-20-10
    - Mulch – 840 kg/Ha (750 lbs./A) conwedd fiber
- Trees – Hand planted pine and black locust
- Intended land use – Commercial development or wildlife habitat
- Seed mixture
    - Kentucky 31 fescue – 27 kg/Ha (25 lbs./A)
    - Redtop – 12 kg/Ha (10 lbs./A)
    - Serecia Lespedeza – 27 kg/Ha (25 lbs./A)
    - Crownvetch – 7 kg/Ha (5.5 lbs./A)
    - Black locust – 7 kg/Ha (5.5 lbs./A)

TABLE 18. EQUIPMENT USED AT MINE SITE PA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loaders				
Cat 988	1	7 yd^3	< 2	Good
Cat 992	1	10½ yd^3	< 2	Good
Dozers				
Cat D-9	2	Varies	< 2	Good
Cat D-7	1	–	< 2	Good
Trucks (off-road)				
Cat 773	3	35 T	< 2	Good
Drill	1	9"	< 2	Good

Head-of-Hollow Fill

Fill Description
- Volume – 229,000 cubic m (300,000 cubic yds.)
- Slope – Average slope 24°
- Spoil haulage distance – 0.4 km (0.25 mile)

Site Preparation
- Sediment pond
  - Location – 31 m (100 ft.) from toe of fill
  - Type – Excavated
  - Size – Capacity 154 cubic m (0.125 ac.-ft.)
- Erosion control – Diversion ditches
- Clearing and grubbing
  - Type vegetation – Northern Deciduous forest
  - Removal method – Cut and dozered
  - Disposition – Buried and windrowed

Fill Construction
- Underdrainage system – Sandstone core
- Spoil placement – Adjacent to rock core by trucks and dozers
- Lift design – 5 lifts, slope 26°
- Final fill form
  - Slope – Maximum outslope 26°
  - Area – 0.6 Ha (1.5 A)

Reclamation
- Regrading – Dozers, cleat tracks used as seed traps
- Revegetation
  - Area – 0.6 Ha (1.5 A)
  - Fertilizer – 561 kg/Ha (500 lbs./A) of 10-20-10
  - Mulch – 840 kg/Ha (750 lbs./A) conwedd fiber
- Seed mixture – Kentucky 31 fescue – 27 kg/Ha (25 lbs./A)
  - – Redtop – 12 kg/Ha (10 lbs./A)
  - – Serecia Lespedeza – 27 kg/Ha (25 lbs./A)
  - – Crownvetch – 7 kg/Ha (5.5 lbs./A)
  - – Black locust – 7 kg/Ha (5.5 lbs./A)

Water Quality
- Periodic samples – See Table 19
- Weather condition during collection – See Table 20

TABLE 19. WATER QUALITY AT MINE SITE PA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	September	6.1	16	4	.1	40	40	114	28	8.8	20	.5	<.1	<.01	.08	<.01	<.03	.03	225
	November	6.4	14	0	-	5	30	170	<1	-	-	-	-	-	-	-	-	.04	235
	December	6.5	14	0	.2	11	45	200	12	37	21	.41	.1	<.01	.39	<.01	<.03	.12	240
	April	6.8	36	-16	.1	2	28	-	-	33	24	.06	.1	.01	.08	.01	.03	.01	330
	AVERAGE	-	20	-3	.1	15	36	161	14	26	22	.32	.1	.01	.18	.01	.03	.05	258

Note: All units mg/l except where noted.

TABLE 20. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE PA

YEAR	MONTHS	TEMPERATURE ° C (° F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*FEBRUARY*	2 (35)	21 (70)	0.61 (0.24)	4	0.13 (0.05)	70	69.55 (27.38)	58	23.5 (14.6)	28	Cloudy, rain
	APRIL	0 (32)	20 (68)	0	1	0.08 (0.03)	40	69.47 (27.35)	30	7.1 (4.4)	31	Sunny
	JUNE	18 (64)	30 (86)	0	1	0.15 (0.06)	90	69.88 (27.51)	52	12.2 (7.6)	19	Cloudy
	SEPTEMBER	12 (54)	23 (73)	0	4	3.6 (1.4)	90	70.36 (27.70)	40	7.4 (4.6)	14	Cloudy
	NOVEMBER	-3 (26)	10 (50)	0.08 (0.03)	2	Trace	70	69.62 (27.41)	36	15.5 (9.6)	27	Partly cloudy
1977	*APRIL*	12 (53)	24 (75)	0	1	0.25 (0.10)	100	70.21 (27.64)	48	18.3 (11.4)	14	Cloudy and warm

MINE SITE EA

Physical Description

Topography
- Location – Cumberland Plateau, eastern Kentucky
- Terrain – High steep slopes
- Elevation – 329-402 m (1,080-1,320 ft.)
- Slope – 25° near head; 5° at toe of hollow
- Area – 103 Ha (255 A)
- Vegetation – Mixed Mesophytic oak-maple forest, second or third generation climax

Climatology
- Local storms – 30 to 50 days/year
- Runoff – 38 cm (15 in.)/year
- Erosion potential – Severe
- Annual precipitation – 114 cm (45 in.)
- Local temperature – See Figure 20
- Local precipitation – See Figure 21

Geology
- Strata – See Table 21
- Age of formation – Lower-Middle Pennsylvanian
- Coal seams – 5A, 7, 8, 9 and 9 rider
- Coal quality (average)
  - BTU – 11,650
  - Sulfur – 0.8%
  - Ash – 13%
  - Moisture – 6%

Pedology
- Major soil association – Jefferson-Shelocta
- Description – Acidic sandstone, siltstone and shale; sod deep, well drained and gravelly or stony
- Minor soils – Steinsburg, Rigley, Dekalb, Lily, Wernock, Allegheny, Pope, Stendal, and Latham

Mining Technique: Mountaintop Removal

Operations
- Area – 89 Ha (219 A)
- Employees – 50
- Work schedule – Two 10-hour shifts/day, five days/week
- Coal series – Upper Pottsville-Lower Allegheny

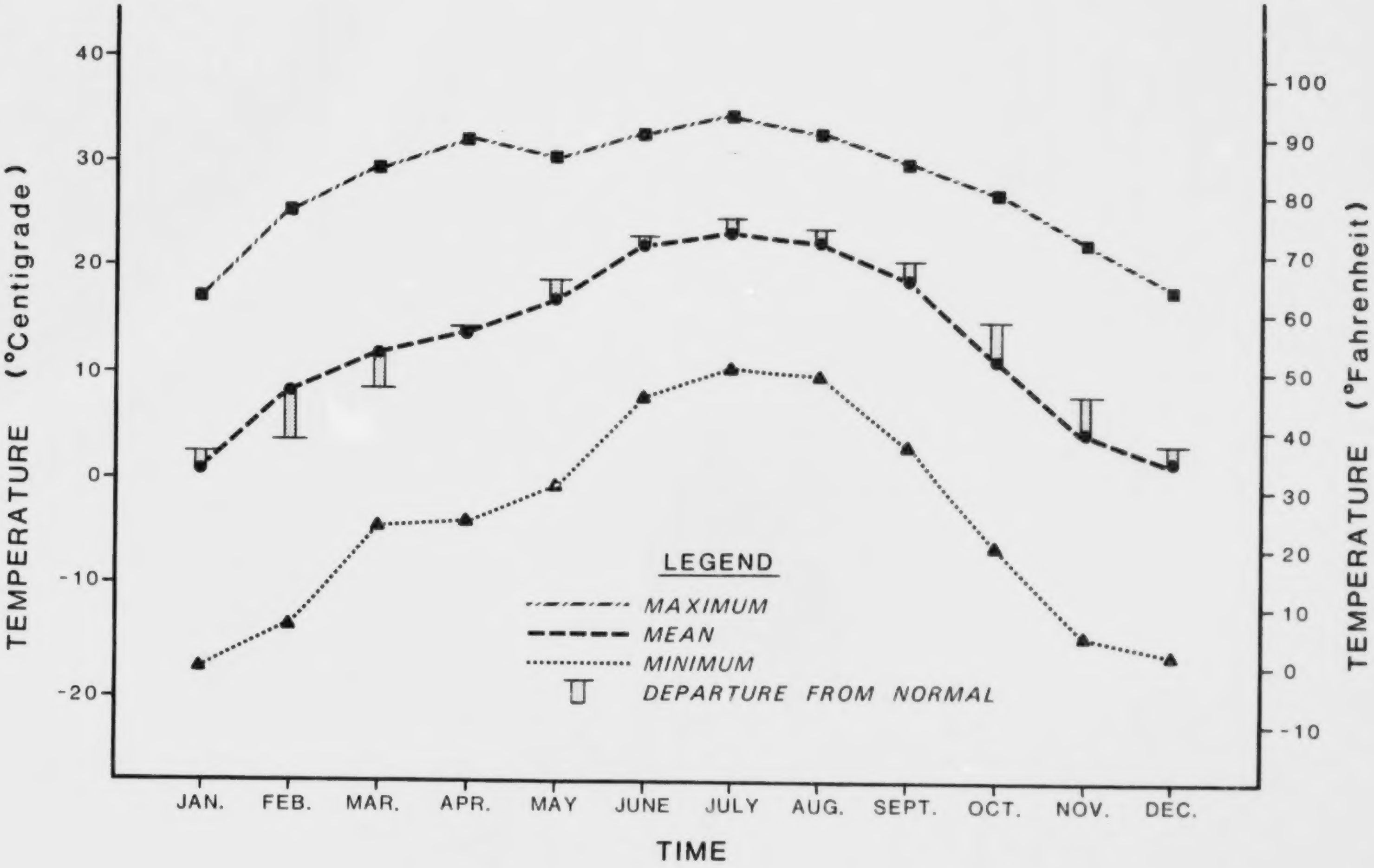


Figure 20. Temperature records in 1976 by month for mine site EA

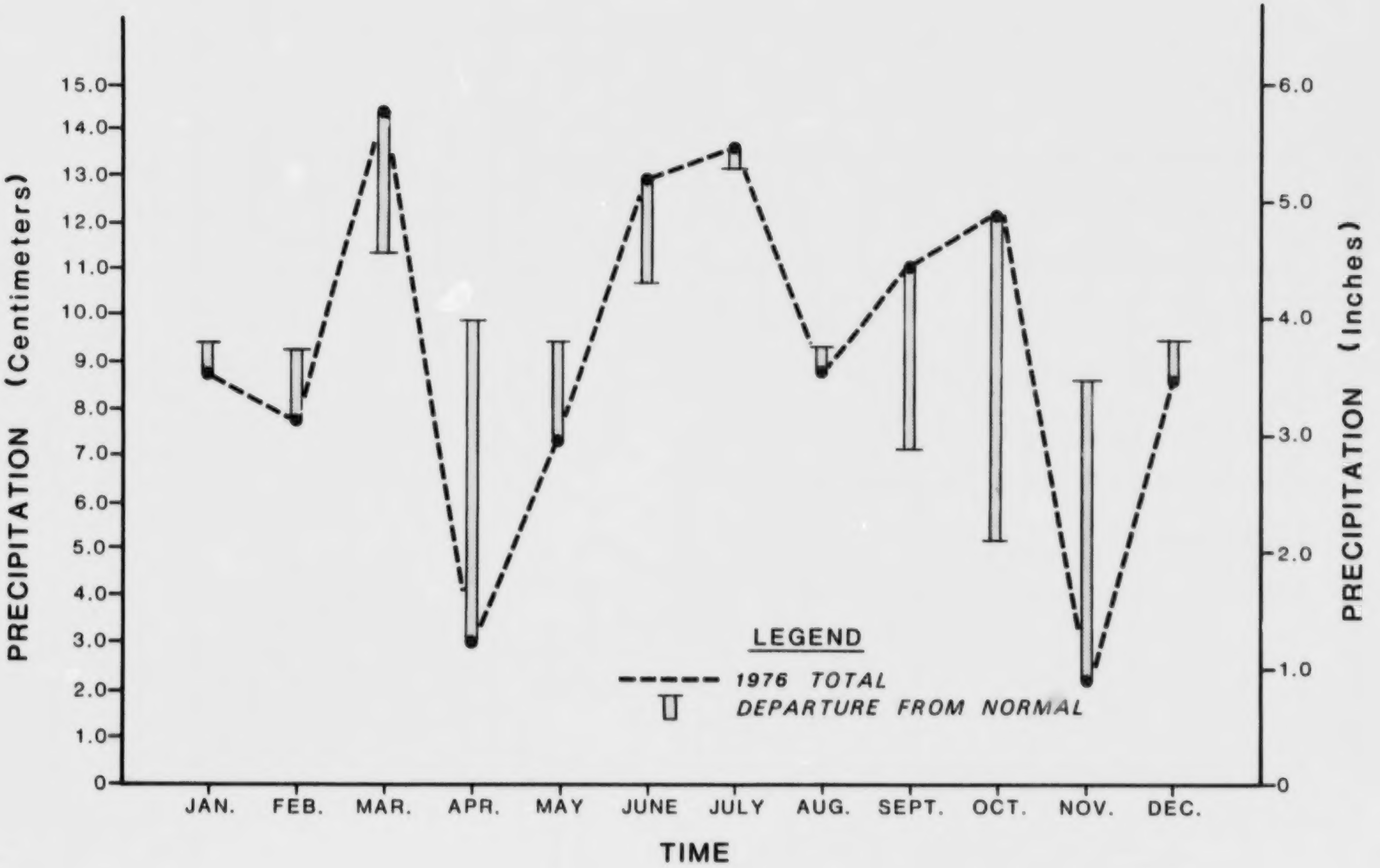


Figure 21. Total precipitation in 1976 by month for mine site EA

TABLE 21. OVERBURDEN AT MINE SITE EA

CORE CHARACTERISTICS		ROCK TYPE			TOTAL
		SANDSTONE	SHALE	SOIL	
1	THICKNESS	3.4 (11.2)	23.4 (76.8)	-	26.8 (88.0)
	PERCENT	12.7	87.3	0	
2	THICKNESS	29.9 (98.0)	18.6 (61.0)	6.1 (20.0)	54.6 (179.0)
	PERCENT	54.8	34.1	11.2	
3	THICKNESS	9.1 (30.0)	3.4 (11.0)	3.6 (12.0)	16.2 (53.0)
	PERCENT	56.6	20.8	22.6	
AVG.	THICKNESS	14.1 (46.4)	15.1 (49.6)	4.9 (16.0)	34.1 (112.0)
	PERCENT	41.4	44.3	14.3	100.0

Thickness is in meters and (feet).

Equipment – See Table 22

Mining Techniques

- Exploration – Stratigraphic core borings
- Erosion control – Sediment ponds and diversion ditches
- Drilling and blasting
  - Drill depth – 6 to 21 m (7 ft. to 20 ft.)
  - Drill hole spacing – 3 m (10 ft.) centers
  - Drill hole size – 23 cm (9 in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and delays
  - Detonation pattern – Simultaneous rows
  - Explosive load – 104 to 454 kg (230 to 1,000 lbs.)/hole
- Overburden – See Table 21
- Spoil transport – By truck, less than one mile to hollow fill
- Coal removal
  - Production – 453,590 metric (500,000 short) tons/year
  - Method – Truck

Haulage – 11.3 to 19.3 km (7 to 12 miles)
Market – Utility steam

Reclamation
- Regrading – Dozers; final slope approximately 20°
- Revegetation
  - Area – 89 Ha (219 A)
  - Method – Hydroseeder used
  - Fertilizer – 336 to 392 kg/Ha (300 to 350 lbs./A) of 16-32-8
  - Mulch – 1121 kg/Ha (1,000 lbs./A) wood fiber
- Trees – 5 kg/Ha (5 lbs./A) locust seed used with no seedlings planted
- Intended land use – "Game Lands", farming, grazing
- Seed mixture – 90 kg/Ha (80 lbs./A)
  - Winter rye – 27 kg/Ha (25 lbs./A)
  - Kentucky 31 fescue – 22 kg/Ha (20 lbs./A)
  - Redtop – 3 kg/Ha (3 lbs./A)
  - Yellow clover – 13 kg/Ha (12 lbs./A)
  - Crownvetch – 5 kg/Ha (5 lbs./A)
  - Serecia Lespedeza – 13 kg/Ha (12 lbs./A)

TABLE 22. EQUIPMENT USED AT MINE SITE EA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loader				
Cat 988	2	7 yd.	4	Good
Cat 992	1	10½ yd.	5	Good
Int. Harvester H400	2	10-12 yd.	3	Good
Michigan 475	2	–	2	Good
Dozer				
Cat D-9	6	–	Varies	Good
Trucks (off-road)				
Euclid R-50	2	50 T	1	Excellent
Terex 33-09	4	–	3	Excellent
Drill				
Robbins	3	9"	Varies	Good
Grader				
Cat 12	1	–	4	Good
Trucks (coal haulers)				
Contracted				

Head-of-Hollow Fill

Fill Description	
· Volume	- 1.15 million cubic m (1.5 million cubic yds.)
· Slope	- Sidewalls 22° to 29°, 7° at toe of fill
· Spoil haulage distance	- Less than 1.6 km (1 mile)
Site Preparation	
· Sediment pond	
Location	- 304 m (1,000 ft.) from toe of fill
Type	- Sandstone/shale rock dam, secondary "dugout" structures also used
· Erosion control	- Diversion ditches around top of fill directed toward silt basin; also 10° cut across fill face
· Clearing and grubbing	
Type vegetation	- Second and third growth oak and maple
Removal method	- Cut and dozered
Disposition	- Windrowed at base of fill
Fill Construction	
· Underdrainage system	- Fractured sandstone french drain formed by natural segregation
· Spoil placement	- Free dumped from top of fill
· Lift design	- No lifts
· Final fill form	
Slope	- Overall average 20°, maximum outslope 25°
Area	- 15 Ha (36 A)
Reclamation	
· Regrading	- Dozers; overall slope approximately 20°
· Revegetation	
Area	- 15 Ha (36 A)
Fertilizer	- 336 to 392 kg/Ha (300 to 350 lbs./A) of 16-32-8
Mulch	- 1121 kg/Ha (1,000 lbs./A) wood fiber
· Seed mixture	- As described for mountaintop revegetation
Water Quality	
· Periodic samples	- See Table 23
· Weather condition during collection	- See Table 24

TABLE 23. WATER QUALITY AT MINE SITE
EA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	October	7.4	62	0	-	90	60	230	60	25	-	-	-	-	-	-	-	.43	265
	November	7.2	74	0	.95	5	90	204	1	39	17	.88	<.1	<.01	.09	<.01	<.03	.36	295
	AVERAGE	-	68	0	.95	48	75	217	30	32	17	.88	< .1	<.01	.09	< .01	<.03	.40	280

Note: All units mg/l except where noted.

TABLE 24. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE EA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	DAILY MAX		NO. DAYS	AMOUNT CM (IN)				SPEED KPH (MPH)	DIRECTION	
1976	APRIL	7 (45)	27 (80)	0	6	0.38 (0.15)	70	73.84 (29.07)	40	6.4 (4.0)	21	Cloudy, cool and damp
	JUNE	16 (60)	19 (67)	1.73 (0.68)	1	3.71 (1.46)	100	73.56 (28.96)	73	6.0 (3.7)	3	Cloudy, cool and damp
	AUGUST	19 (67)	29 (85)	0	10	0.91 (0.36)	100	73.86 (29.08)	93	7.6 (4.7)	15	Hot, humid and hazy
	OCTOBER	5 (41)	18 (65)	0	3	0.33 (0.13)	10	73.53 (28.95)	59	12.4 (7.7)	23	Clear and cool
	NOVEMBER	6 (42)	16 (60)	0	9	0.18 (0.07)	0	73.36 (28.88)	41	15.9 (9.9)	26	Cold, clear and sunny
1977	APRIL	10 (50)	30 (86)	0	13	0.10 (0.04)	60	73.79 (29.05)	33	8.5 (5.3)	14	Partially cloudy and hot

MINE SITE FA

Physical Description

Topography

- Location – Cumberland Plateau, eastern Kentucky
- Terrain – Large steep erosion valleys and mountains
- Elevation – 305 m (1,000 ft.) to 732 m (2,400 ft.) above sea level
- Slope – Vary from 31° on the slopes to 11° in the valley bottoms
- Area – 94 Ha (232 A)
- Vegetation – Third to fourth generation Mesophytic oak-maple forest

Climatology

- Local storms – Intense thunderstorms 45 days/year
- Runoff – 51 cm (20 in.) mean annual
- Erosion potential – Severe
- Annual precipitation – 127 cm (50 in.)
- Local temperature – See Figure 22
- Local precipitation – See Figure 23

Geology

- Strata – See Table 25
- Age of formation – Lower Pennsylvanian
- Coal seams – Lower and Middle Hanse
- Coal quality (average)
  - BTU – 13,800
  - Sulfur – 1.5%
  - Ash – 10%
  - Moisture – 2%

Pedology

- Major soil association – Shelocta-Gilpin (65%)
- Description – Deep, well drained soil covered by woodland
- Minor soils – Remaining 35% of association composed of Latham, Dekalb, Whitby, Morehead, Cuba and Stendal

Mining Technique: Mountaintop Removal

Operations

- Area – 71 Ha (175 A)
- Employees – 75

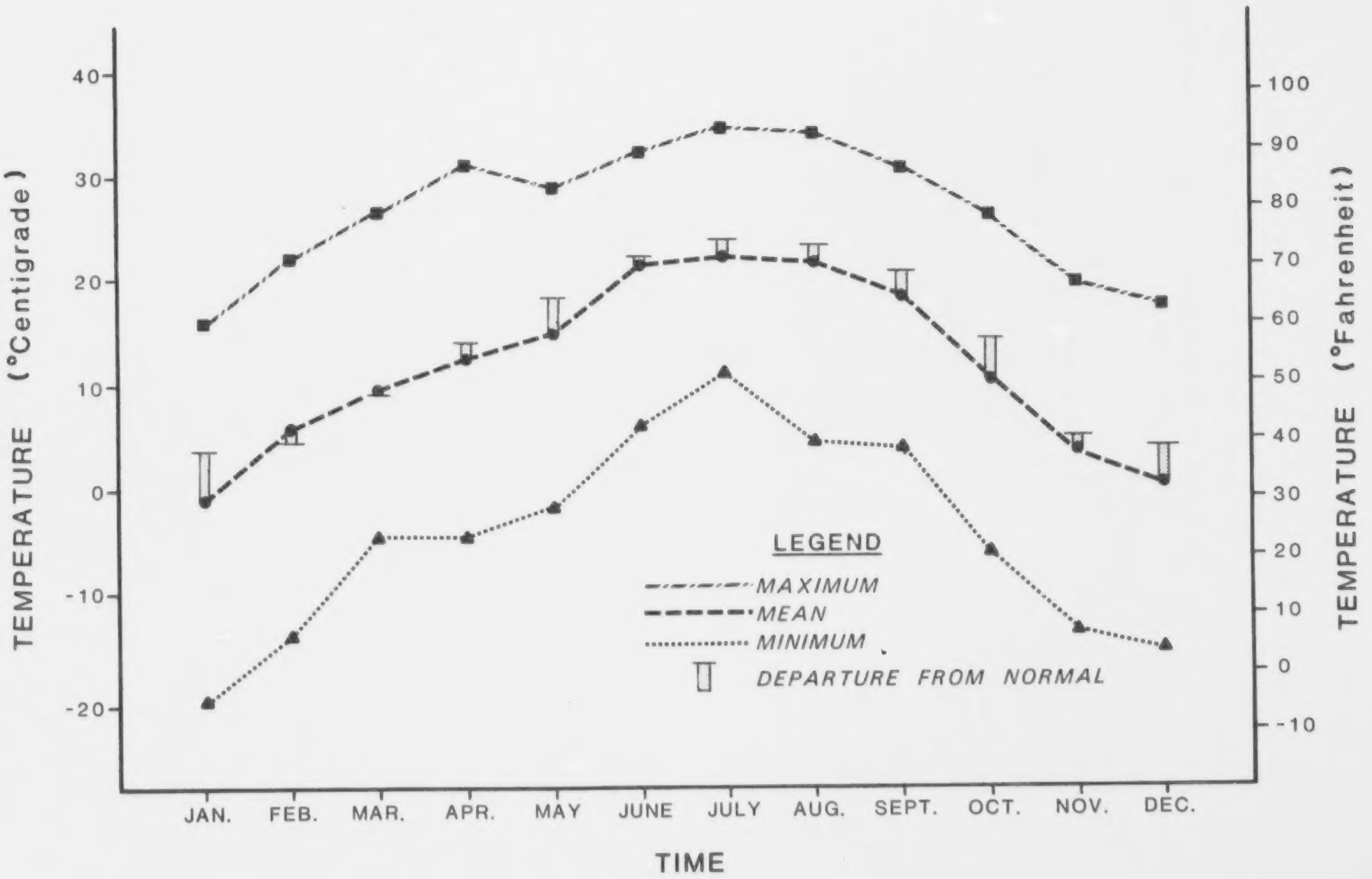


Figure 22. Temperature records in 1976 by month for mine site FA

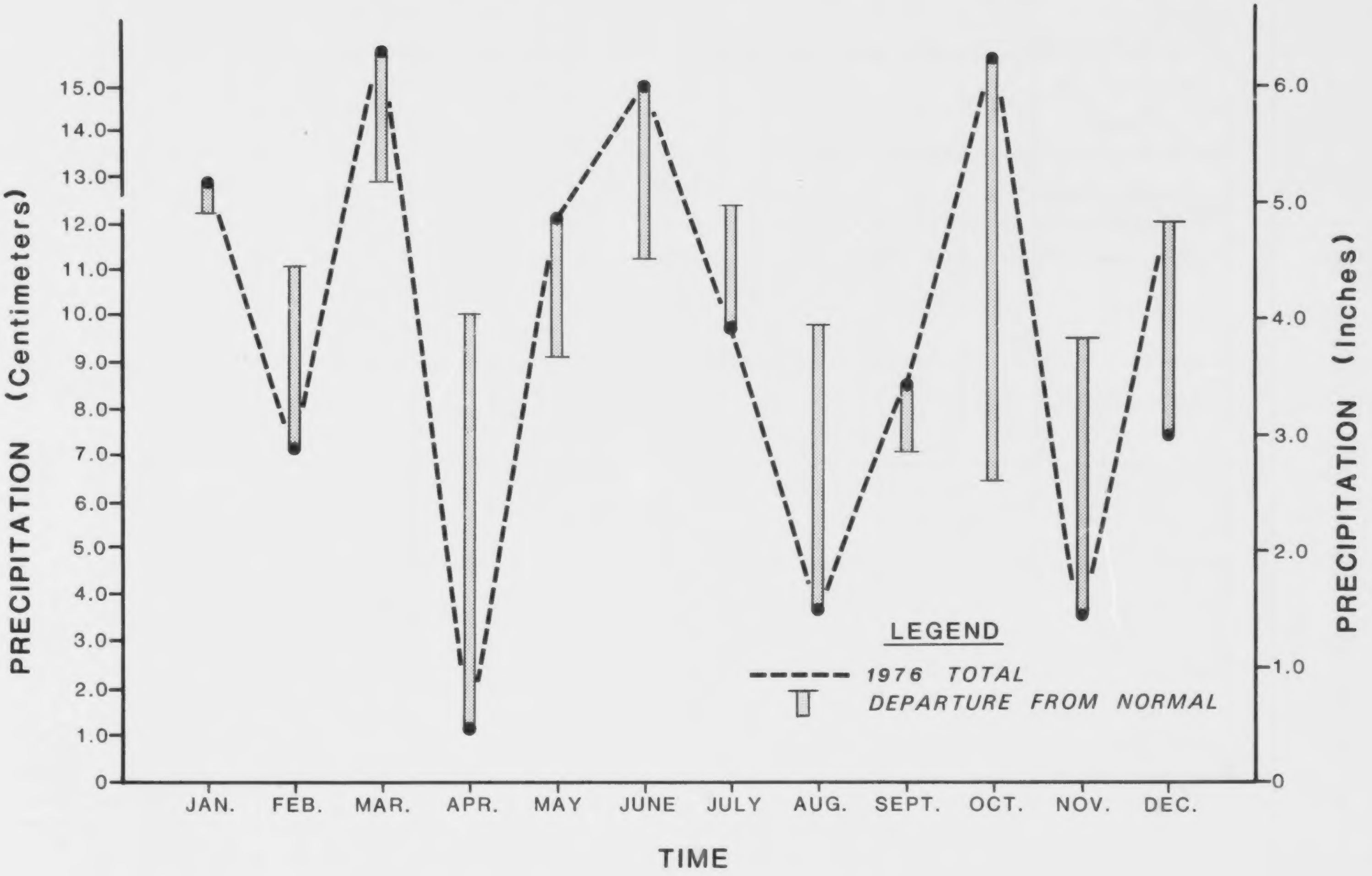


Figure 23. Total precipitation in 1976 by month for mine site FA

TABLE 25. OVERBURDEN AT MINE SITE FA

CORE CHARACTERISTICS		ROCK TYPE							TOTAL
		SANDSTONE WITH CLAY	GRAY SHALE	GRAY SANDY SHALE	GRAY SANDSTONE	CLAY	SANDSTONE WITH SHALE	SHALE WITH CLAY	
1	THICKNESS	2.13 (7)	6.40 (21)	.61 (2)	13.4 (44)	–	9.75 (32)	2	32.92 (108)
	PERCENT	6	20	2	42		28	2	100
2	THICKNESS	–	21.03 (69)	–	2.74 (9)	–	6.1 (20)	–	29.9 (98)
	PERCENT		70		9		21		100
3	THICKNESS	3.66 (12)	14.33 (47)	15.24 (50)	7.01 (23)	4.57 (15)	8.84 (29)	1.52 (5)	5.17 (181)
	PERCENT	7	26	28	12	8	16	3	100
4	THICKNESS	–	5.49 (18)	–	.91 (3)	2.7 (9)	6.10 (20)	4.57 (15)	19.81 (65)
	PERCENT		28		4	14	31	23	100
5	THICKNESS	–	8.23 (27)	.31 (1)	4.88 (16)	3.66 (12)	9.14 (30)	3.1 (10)	29.26 (96)
	PERCENT		28	1	17	13	31	10	100
AVG.	THICKNESS	2.90 (9.5)	11.10 (36.4)	5.40 (17.7)	5.79 (19)	3.66 (12)	7.99 (26.2)	2.44 (8)	39.26 (128.8)
	PERCENT	4	32	10	17	7	24	6	100

Thickness is in meters and (feet).

- Work schedule – Two 10-hour shifts daily, five days/week
- Coal series – Middle Pottsville

Equipment – See Table 26

Mining Techniques

- Exploration – Stratigraphic core borings
- Erosion control – Diversion ditches and sediment ponds
- Drilling and blasting
  - Drill depth – 27 to 35 m (90 ft. to 115 ft.)
  - Drill hole spacing – 5.5 to 6.4 m (18 ft. to 21 ft.)
  - Drill hole size – 23 to 27 cm (9 in. to 10 5/8 in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and delays
  - Detonation pattern – Simultaneous row
  - Explosive load – 204 to 250 kg (450 to 550 lbs.) with some chambering
- Overburden – See Table 25
- Spoil transport – By front-end loaders and trucks, haulage distance 0.4 to 0.8 km (¼-½ mile) round trip
- Coal removal
  - Production – 271,000 metric (300,000 short) tons/year
  - Method – Front-end loaders and trucks
  - Haulage – 6.4 km (4 miles) round trip
  - Market – Utility steam

Reclamation

- Regrading – Bulldozers used; maximum 20° slope
- Revegetation
  - Area – 71 Ha (175 A)
  - Method – Seed sprayed with hydroseeder over cleat tracks left by dozer
  - Fertilizer – 392 kg/Ha (350 lbs./A) of 18-46-0
  - Mulch – 1682 kg/Ha (1,500 lbs./A) wood fiber
- Trees – 2470/Ha (1,000/A) hand planted white and scotch pines
- Intended land use – Grazing and agriculture
- Seed mixture
  - Kentucky 31 fescue – 35 kg/Ha (30 lbs./A)
  - Annual ryegrass – 12 kg/Ha (10 lbs./A)
  - Perennial ryegrass – 12 kg/Ha (10 lbs./A)
  - Red clover – 12 kg/Ha (10 lbs./A)
  - Kobe Lespedeza – 13 kg/Ha (12 lbs./A)

TABLE 26. EQUIPMENT USED AT MINE SITE FA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loader				
Cat 992	1	10 yd^3	2	Good
Cat 992	1	11 yd^3	7	Good
Cat 988 (coal)	1	6 yd^3	6	Good
Hough 400C	1	10 yd^3	3	Good
Trucks (off-road)				
Euclid R-75	8	75 T	2	Good
Dozer				
Kumatsu 355	1	–	1	Excellent
Cat D-9	3	–	1 1/2-3 yrs	Good
I.H. TD 25 C	1	–	3	Good
Cat 984 (rubber tired)	1	–	1/2	Excellent
Drag				
Marion	1	–	5	Good
Shovel				
Marion	2	–	5	Good
Drills				
Bucyrus-Erie 45R	1	10 5/8"	5	Good
Robbins TD-30 (mounted on International Tractor)	1	9"	5	Good
Robbins 7584 (truck mounted)	1	9"	5	Good
Robbins 7584 (truck mounted)	1	9"	10	Good
Graders				
Cat 16	1	–	5	Good
Trucks (coal)				
Mack 26T	10	26T	Contracted	–
Hydroseeder	1	–	2	Good

Head-of-Hollow Fill

Fill Description
- Volume – 1,975,000 cubic m (2.5 million cubic yds.)
- Slope – Sidewalls 15°; slope at toe 5°
- Spoil haulage distance – 0.4 to 0.8 km (¼ to ½ mile) from mine site to hollow

Site Preparation
- Sediment pond
  - Location – Below toe of fill
  - Type – Excavated
  - Size – Surface area 0.9 Ha (2.1 A)
- Erosion control – Diversion ditches sloped to sediment pond; windrowed check dam also used around hollow
- Clearing and grubbing
  - Type vegetation – Third and fourth generation oak-maple forest
  - Removal method – Cut and dozered
  - Disposition – Windrowed at base of fill

Fill Construction
- Underdrainage system – Fractured sandstone french drain formed by natural segregation
- Spoil placement – Free dumped at head of hollow
- Lift design – No lifts
- Final fill form
  - Slope – Maximum of 20°
  - Area – 23 Ha (57 A)

Reclamation
- Regrading – Dozers
- Revegetation
  - Area – 23 Ha (57 A)
  - Fertilizer – 392 kg/Ha (350 lbs./A) of 18-40-0
  - Mulch – 1682 kg/Ha (1,500 lbs./A) wood fiber
- Seed mixture – Kentucky 31 fescue – 35 kg/Ha (30 lbs./A)
  - – Annual ryegrass – 12 kg/Ha (10 lbs./A)
  - – Perennial ryegrass – 12 kg/Ha (10 lbs./A)
  - – Clover – 12 kg/Ha (10 lbs./A)
  - – Kobe Lespedeza – 13 kg/Ha (12 lbs./A)

Water Quality
- Periodic samples – See Table 27
- Weather condition during collection – See Table 28

TABLE 27. WATER QUALITY AT MINE SITE FA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	*FEBRUARY*	5.9	12	20	<.01	<5	260	450	18	30	22	7.9	<.1	<.01	.36	<.01	.30	<.01	690
	APRIL	7.8	198	0	1.0	15	1875	3675	11	296	365	1.4	<.1	<.01	.02	.01	.10	.04	3700
	AUGUST	7.5	236	10	.32	10	1950	3700	19	280	350	1.4	<.1	<.01	.08	<.01	.05	.01	3075
	OCTOBER	7.9	286	0	.71	5	1990	3570	6	424	6.2	3.8	.3	<.01	.71	<.01	.09	.70	3060
	NOVEMBER	7.6	246	4	.83	<5	1700	2808	3	350	290	5.5	<.1	<.01	.06	<.01	.04	<.01	2670
	APRIL	7.6	322	-364	60	15	1924	3391	31	36	8.4	4.8	.3	<.01	.35	< .01	.13	<.01	2970
	AVERAGE	-	218	-55	10	9	1617	2932	15	236	174	4.8	.17	<.01	.26	<.01	.12	.03	2694
INFLUENT	*AUGUST*	7.4	280	8	.09	<5	2400	4470	16	328	470	.82	<.1	<.01	.06	< .01	.09	.02	3550
	NOVEMBER	7.4	325	0	.4	<5	2240	3862	2	500	450	2.9	.1	<.01	.21	< .01	<.12	<.01	3400
	AVERAGE	-	302	4	.24	≤5	2320	4166	9	414	460	1.86	≤.1	≤.01	.14	≤.01	.10	.02	3475

Note: All units mg/l except where noted.

TABLE 28. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE FA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*FEBRUARY*	0 (32)	7 (44)	0	1	1.25 (0.49)	0	74.37 (29.28)	42	5.6 (3.5)	23	Sunny and clear
	APRIL	7 (45)	29 (85)	0	7	0.43 (0.17)	80	73.86 (29.08)	33	1.6 (1.0)	4	Sunny, hot and dry
	AUGUST	18 (64)	26 (79)	Trace	10	0.25 (0.10)	100	73.94 (29.11)	82	3.9 (2.4)	27	Hot, humid and hazy
	OCTOBER	4 (39)	22 (71)	0	3	0.13 (0.05)	0	73.74 (29.03)	59	6.8 (4.2)	25	Clear and sunny
	NOVEMBER	-1 (31)	13 (55)	0	10	0.20 (0.08)	20	73.46 (28.92)	49	18.5 (11.5)	25	Cool, overcast
1977	*APRIL*	10 (50)	29 (84)	0	13	0.23 (0.09)	100	73.91 (29.10)	81	2.7 (1.7)	29	Hot, humid and overcast

MINE SITE GA

Physical Description

Topography
- Location – Cumberland Plateau, eastern Kentucky
- Terrain – Steep erosion mountains and valleys
- Elevation – 244 m (800 ft.) to 488 m (1,600 ft.)
- Slope – 33° on ridgetops; 5° in hollows
- Area – 20 Ha (50 A)
- Vegetation – Climax third to fourth generation oak-maple forest

Climatology
- Local storms – Intense thunderstorms avg. 45 days/year
- Runoff – Average annual – 38.1 cm (15 in.)
- Erosion potential – Severe
- Annual precipitation – 122 cm (48 in.)
- Local temperature – See Figure 24
- Local precipitation – See Figure 25

Geology
- Strata – See Table 29 and Figure 26
- Age of formation – Lower-Middle Pennsylvanian
- Coal seams – Hazard 5A
- Coal quality (average)
  - BTU – 12,200
  - Sulfur – 1%
  - Ash – 10%
  - Moisture – 6%

Pedology
- Major soil association – Jefferson-Shelocta-Steinsburg (76%)
- Description – Deep well drained, formed in loamy colluvium from acid sandstone, siltstone and shale
- Minor soils – Rigley, Dekalb, Lily, Wernock, Allegheny, Pope, Stendal, and Latham

Mining Technique: Contour Strip

Operations
- Area – 20 Ha (50 A)
- Employees – 80
- Work schedule – Two 10-hour shifts, five days/week
- Coal series – Upper Pottsville

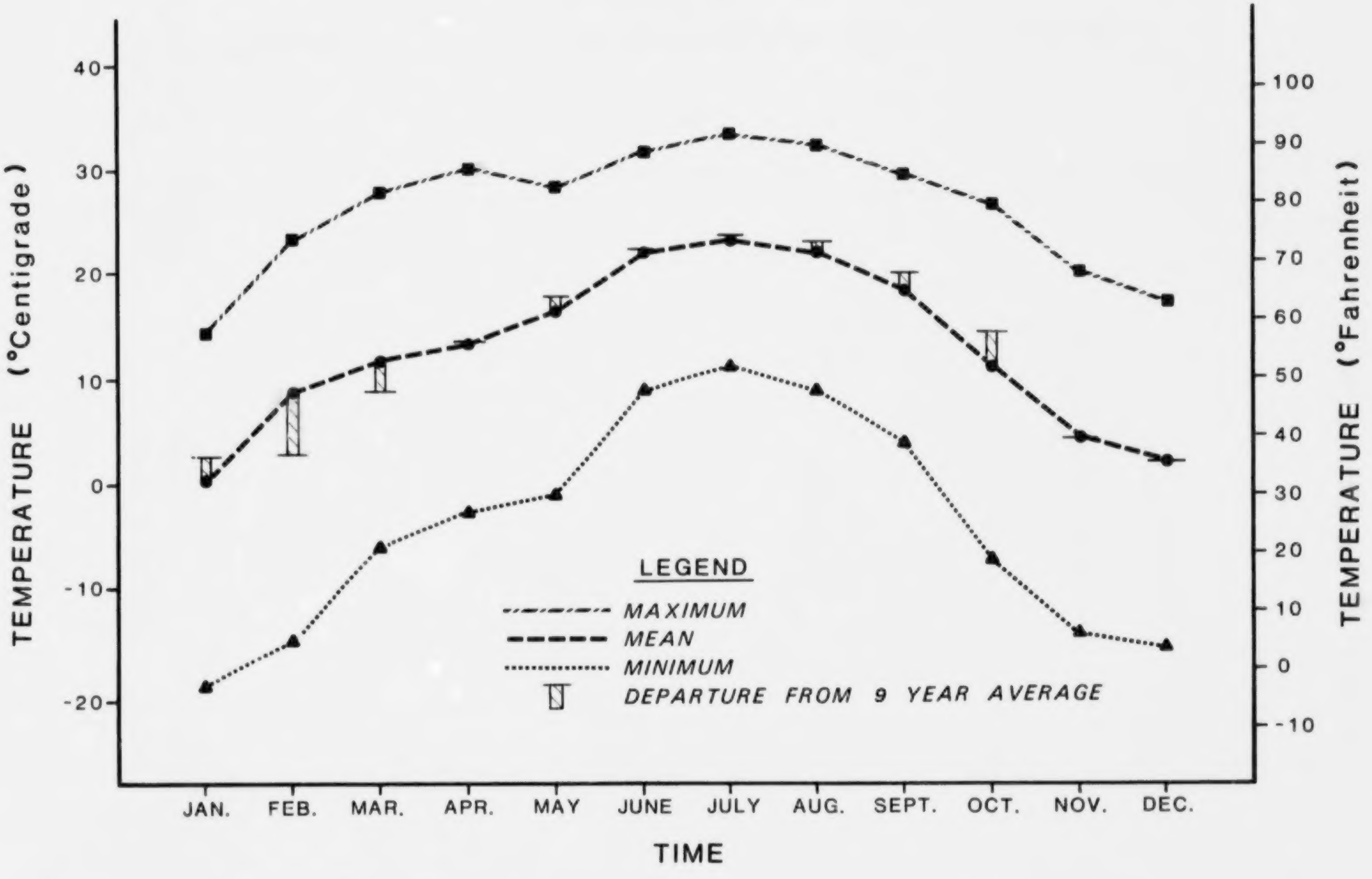


Figure 24. Temperature records in 1976 by month for mine site GA.

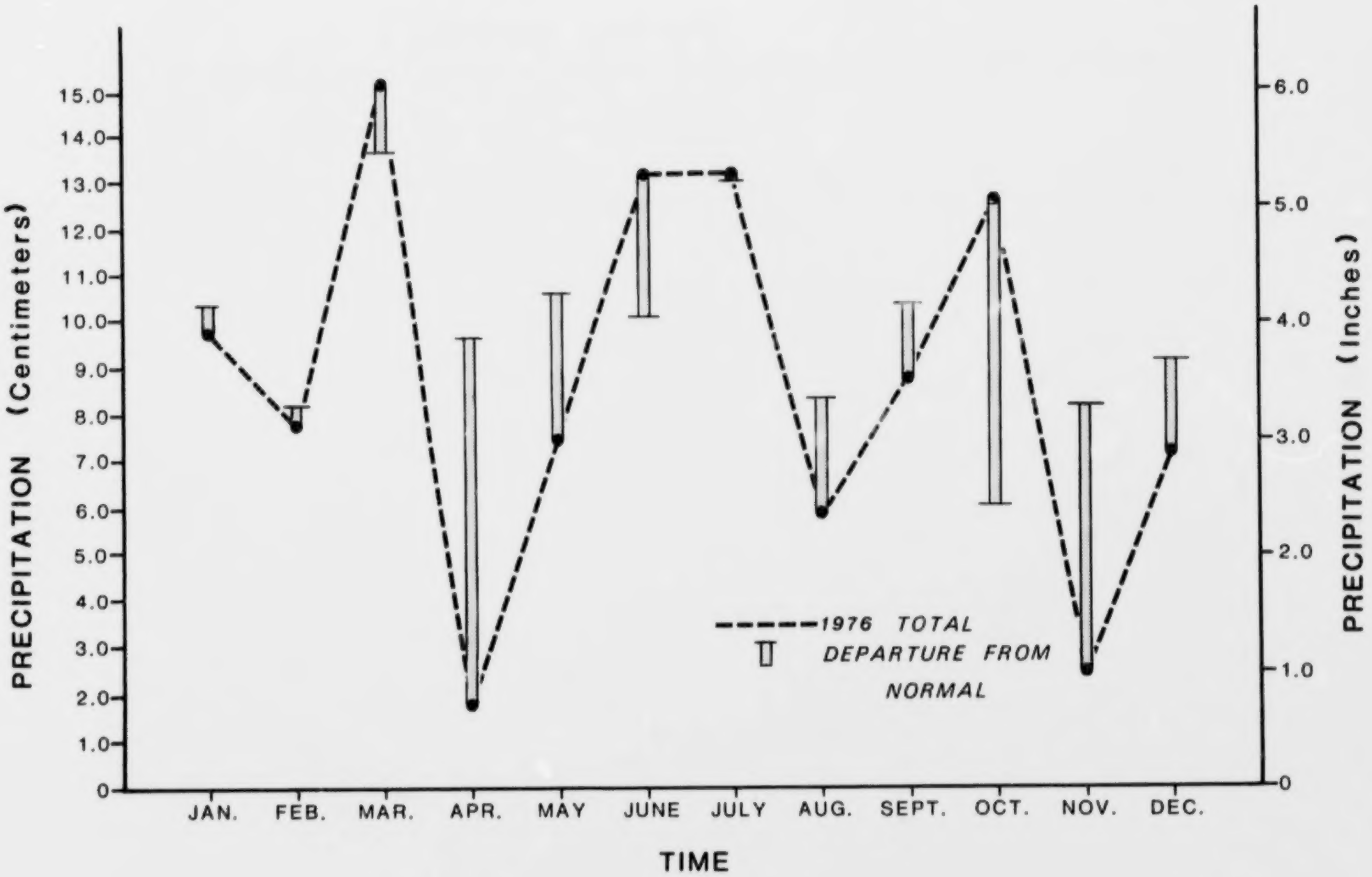


Figure 25. Total precipitation in 1976 by month for mine site GA.

TABLE 29. OVERBURDEN AT MINE SITE GA

CORE CHARACTERISTICS		ROCK TYPE					TOTAL
		COAL	GRAY SHALE	GRAY SANDY SHALE	LIGHT GRAY SANDSTONE	LIGHT BLUE SANDSTONE	
1	THICKNESS	.98 (3.2)	4.27 (14)	1.83 (6)	10.36 (34)	-	17.44 (57.2)
	PERCENT	6	24	10	60	-	100
2	THICKNESS	1.07 (3.5)	1.83 (6)	2.13 (7)	6.40 (21)	-	11.43 (37.5)
	PERCENT	9	16	19	56	-	100
3	THICKNESS	.88 (2.9)	.31 (1)	4.57 (15)	9.14 (30)	-	14.91 (48.9)
	PERCENT	6	2	31	61	-	100
4	THICKNESS	.85 (2.8)	6.10 (20)	-	5.49 (18)	-	12.44 (40.8)
	PERCENT	7	49	-	44	-	100
5	THICKNESS	.95 (3.1)	1.52 (5)	-	10.06 (33)	1.83 (6)	14.36 (47.1)
	PERCENT	7	10	-	70	13	100
6	THICKNESS	1.01 (3.3)	1.52 (5)	-	11.58 (38)	-	14.11 (46.3)
	PERCENT	7	11	-	82	-	100
7	THICKNESS	1.04 (3.4)	.61 (2)	12.50 (41)	-	-	14.14 (46.4)
	PERCENT	7	5	88	-	-	100
AVG.	THICKNESS	.98 (3.2)	2.32 (7.6)	2.99 (9.8)	7.59 (24.9)	1.83 (6.0)	15.71 (51.5)
	PERCENT	6	15	19	48	12	100

Thickness is in meters and (feet).

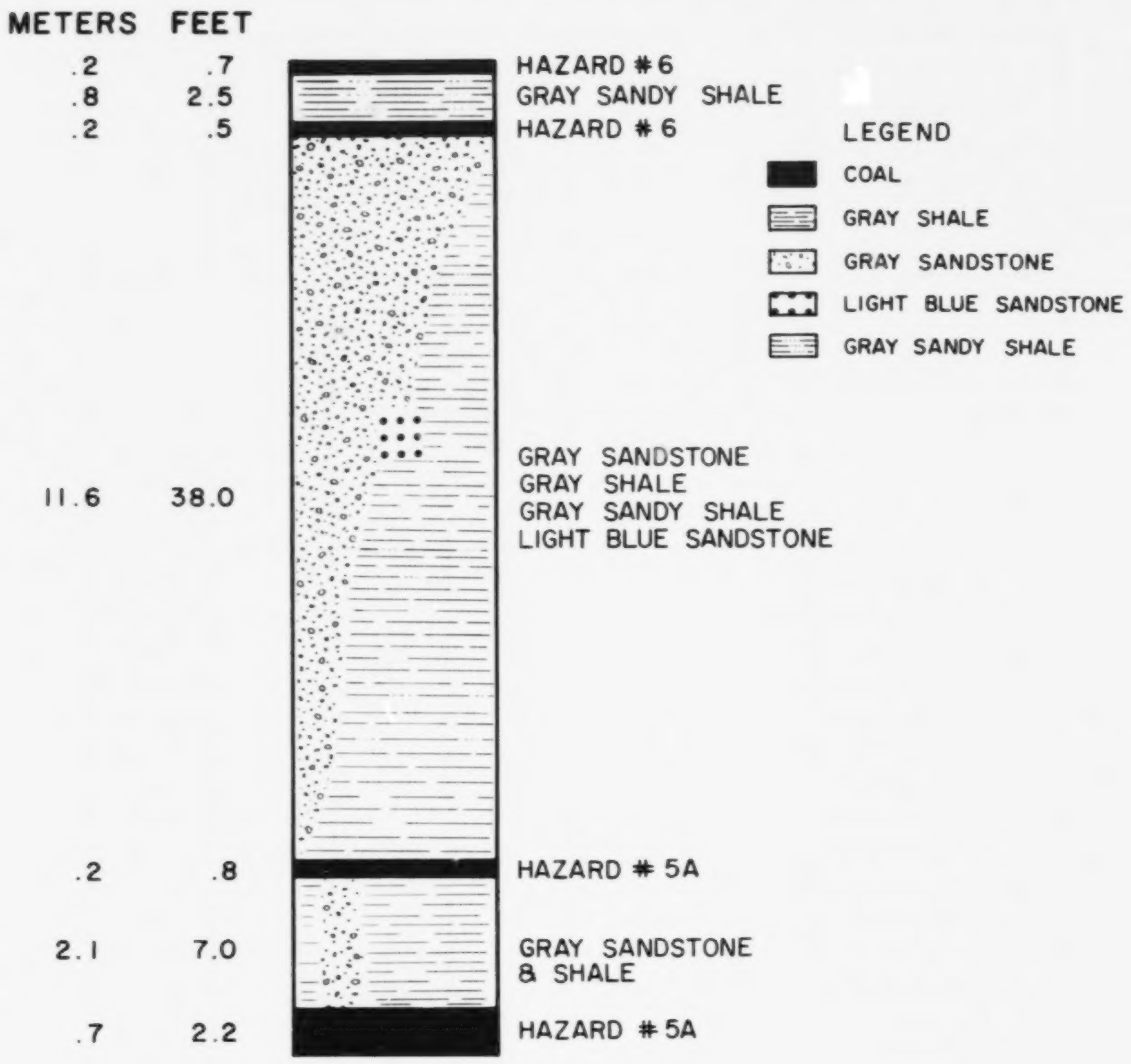

METERS
FEET
.2
.7
HAZARD #6
.8
2.5
GRAY SANDY SHALE
.2
.5
HAZARD # 6
LEGEND
COAL
GRAY SHALE
GRAY SANDSTONE
LIGHT BLUE SANDSTONE
GRAY SANDY SHALE
11.6
38.0
GRAY SANDSTONE
GRAY SHALE
GRAY SANDY SHALE
LIGHT BLUE SANDSTONE
.2
.8
HAZARD # 5A
2.1
7.0
GRAY SANDSTONE
& SHALE
.7
2.2
HAZARD # 5A

Figure 26. Typical rock sequence for mining Hazard #5A.

Equipment – See Table 30

Mining Techniques

- Exploration – Stratigraphic core borings
- Erosion control – Diversion ditches sloped into sediment pond
- Drilling and blasting
  - Drill depth – 9 m (30 ft.)
  - Drill hole spacing – 4.5 m (15 ft.) centers
  - Drill hole size – 27 cm (10 5/8 in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and delays
  - Detonation pattern – Straight rows
  - Explosive load – 68 kg (150 lbs.)/hole
- Overburden – See Table 29
- Spoil transport – Front-end loaders and 35 to 50 ton trucks
- Coal removal
  - Production – 270,000 metric (300,000 short) tons/year
  - Method – Removed from pit by front-end loaders and loaded onto trucks
  - Haulage – 32 km (20 miles) round trip
  - Market – Utility steam

Reclamation

- Regrading – Cover soil graded back to highwall, by trucks and dozers
- Revegetation
  - Area – 12 Ha (30 A)
  - Method – Hydroseeder
  - Fertilizer – 1625 kg/Ha (1,450 lbs./A) of 5-10-10
  - Mulch – 5377 kg/Ha (4,800 lbs./A) wood fiber
- Trees – 618 pine trees/Ha (250/A) hand planted
- Intended land use – Farm use, wildlife habitat, mobile home site and other similar uses
- Seed mixture
  - Rye – 42 kg/Ha (37 lbs./A)
  - Wheat – 13 kg/Ha (12 lbs./A)
  - Clover – 3 kg/Ha (3 lbs./A)
  - Crownvetch – 35 kg/Ha (30 lbs./A)

Head-of-Hollow Fill

Fill Description

- Volume – 612,000 cubic m (800,000 cubic yds.)
- Slope – Sidewalls 22°; hollow floor at toe 2°
- Spoil haulage distance – Less than 0.4 km (¼ mile)

TABLE 30. EQUIPMENT USED AT MINE SITE GA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loader				
Cat 992	4	10 1/2 yd.	0-2	Good
Cat 988	1	7 yd.	2	Good
Dozers				
Cat D-7	1	-	1	Good
Cat D-8	2	-	0-2	Good
Cat D-9	5	-	0-2	Good
Kumatsu D-155	1	-	1	Excellent
Kumatsu D-355	1	-	1	Excellent
International TD-25	1	-	3	Good
Pan Scraper				
Cat 641	2	7T	New	Excellent
Trucks (off-road)				
International 350	2	50T	2	Fair
Euclid R-50	2	50T	New	Excellent
Cat 773	2	50T	New	Good
Cat 769	1	35T	1	Good
Trucks (coal)				
Mack	11	22T	Vary	Good
Road Grader				
Cat 12F	1		-	Good
Cat 14D	1		-	Good
Drills				
Ingersol Rand	1	6 3/4"	1	Good
Chicago Pneumatic 650	2	10 5/8"	2	Good
Hydroseeder	1		New	Excellent

Site Preparation
- Sediment pond
  - Location – 427 m (1,400 ft.) from toe of fill
  - Type – Rock dam
  - Size – 2,714 cubic m (2.2 ac.-ft.)
- Erosion control – Diversion ditches, sediment pond, and windrowing of grubbed timber along base of hollow fill
- Clearing and grubbing
  - Type vegetation – Third-fourth generation oak-maple
  - Removal method – Cut and dozered
  - Disposition – Windrowed at base of fill

Fill Construction
- Underdrainage system – Fractured sandstone french drain formed by natural segregation
- Spoil placement – Free-drop from head-of-hollow fill
- Lift design – No lifts
- Final fill form
  - Slope – Maximum 20°; 2-5° on top surface
  - Area – 5 Ha (13 A)

Reclamation
- Regrading – Principal machine: bulldozers
- Revegetation
  - Area – 5 Ha (13 A)
  - Fertilizer – 1,625 kg/Ha (1,450 lbs./A) of 5-10-10
  - Mulch – 5,436 kg/Ha (4,850 lbs./A) wood fiber
- Seed mixture
  - Annual ryegrass – 42 kg/Ha (38 lbs./A)
  - Clover – 3 kg/Ha (3 lbs./A)
  - Crownvetch – 35 kg/Ha (30 lbs./A)
  - Kentucky 31 fescue – 94 kg/Ha (83 lbs./A)
  - Locust seed – 32 kg/Ha (28 lbs./A)

Water Quality
- Periodic samples – See Table 31
- Weather condition during collection – See Table 32

MINE SITE IA

Physical Description

Topography
- Location – Cumberland Plateau, eastern Kentucky
- Terrain – Steep erosion valleys and mountains
- Elevation – 253 m (830 ft.) to 372 m (1,220 ft.)
- Slope – 38° on sidewalls, 1° on toe of hollow
- Area – 364 Ha (900 A)

TABLE 31. WATER QUALITY AT MINE SITE
GA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	April	8.1	328	0	1.0	25	20	680	26	75	45	6.7	.1	.05	.08	<.01	<.03	.02	640
	June	6.9	92	0	2.6	220	260	640	150	59	37	2.7	.7	<.01	.09	<.01	<.03	<.01	630
	August	7.3	102	0	<.01	5	180	424	9	45	35	.03	<.1	<.01	.12	<.01	<.03	<.01	525
	October	7.9	150	0	.59	25	310	640	15	85	89	2.4	<.1	<.01	.16	<.01	<.03	.59	820
	November	6.2	-	4	.1	<5	8.3	54	2	17	2.5	<.01	<.1	<.01	.08	<.01	<.03	.08	50
	AVERAGE	-	136	<1	.86	56	155.7	488	40	56	41.7	2.4	0.2	<.01	.11	<.01	<.03	<.14	533

Note: All units mg/l except where noted.

TABLE 32. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE GA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*APRIL*	9 (49)	30 (86)	0	9	0.23 (0.09)	50	73.36 (28.88)	34	10.0 (6.2)	17	Hot, dry and sunny
	JUNE	14 (57)	26 (78)	0	2	2.13 (0.84)	50	73.71 (29.02)	54	9.3 (5.8)	17	Humid and overcast
	AUGUST	18 (65)	30 (86)	0	9	1.50 (0.59)	90	73.84 (29.07)	50	9.8 (6.1)	5	Hot, humid and overcast
	OCTOBER	3 (37)	24 (76)	0	3	2.87 (1.13)	0	73.96 (29.12)	47	10.9 (6.8)	17	Clear and sunny
	NOVEMBER	-4 (24)	13 (56)	0	9	1.52 (0.60)	0	73.33 (28.87)	37	23.3 (14.5)	21	Cold, clear and sunny
1977	*APRIL*	12 (54)	24 (75)	0.05 (0.02)	1	0.28 (0.11)	100	73.84 (29.07)	73	6.1 (3.8)	15	Cloudy, rain

- Vegetation – Mixed Mesophytic, second-third growth oak-hickory

Climatology
- Local storms – 30 to 50 days/year
- Runoff – 38 cm (15 in.)/year
- Erosion potential – Severe
- Annual precipitation – 101 cm (40 in.)/year
- Local temperature – See Figure 27
- Local precipitation – See Figure 28

Geology
- Strata – Sandstone 60%, shale 40%
- Age of formation – Lower-Middle Pennsylvanian
- Coal seams – Buffalo Creek, Lower and Upper Peach Orchard, and Lower and Upper Broas
- Coal quality (average)
  BTU – 12,500
  Sulfur – 0.8%
  Ash – 5%
  Volatile matter – 6%

Pedology
- Major soil association – Jefferson-Shelocta (76%)
- Description – Principally formed from colluvium
- Minor soils – Steinsburg, Pope and Cuba

Mining Technique: Mountaintop Removal

Operations
- Area – 364 Ha (900 A)
- Employees – 324
- Work schedule – Three 8-hour shifts/day for 356 days/year
- Coal series – Upper Pottsville-Lower Allegheny

Equipment – See Table 33

Mining Techniques
- Exploration – Historical records and stratigraphic cores
- Erosion control – Road berms, diversion ditches, and sediment ponds
- Drilling and blasting
  Drill depth – 30 m (100 ft.)
  Drill hole spacing – 8 or 9 m (26 ft. or 30 ft.) centers
  Drill hole size – 27 cm (10 5/8 in.)
  Type explosive – ANFO
  Type detonation – Electric cap
  Detonation pattern – Simultaneous rows

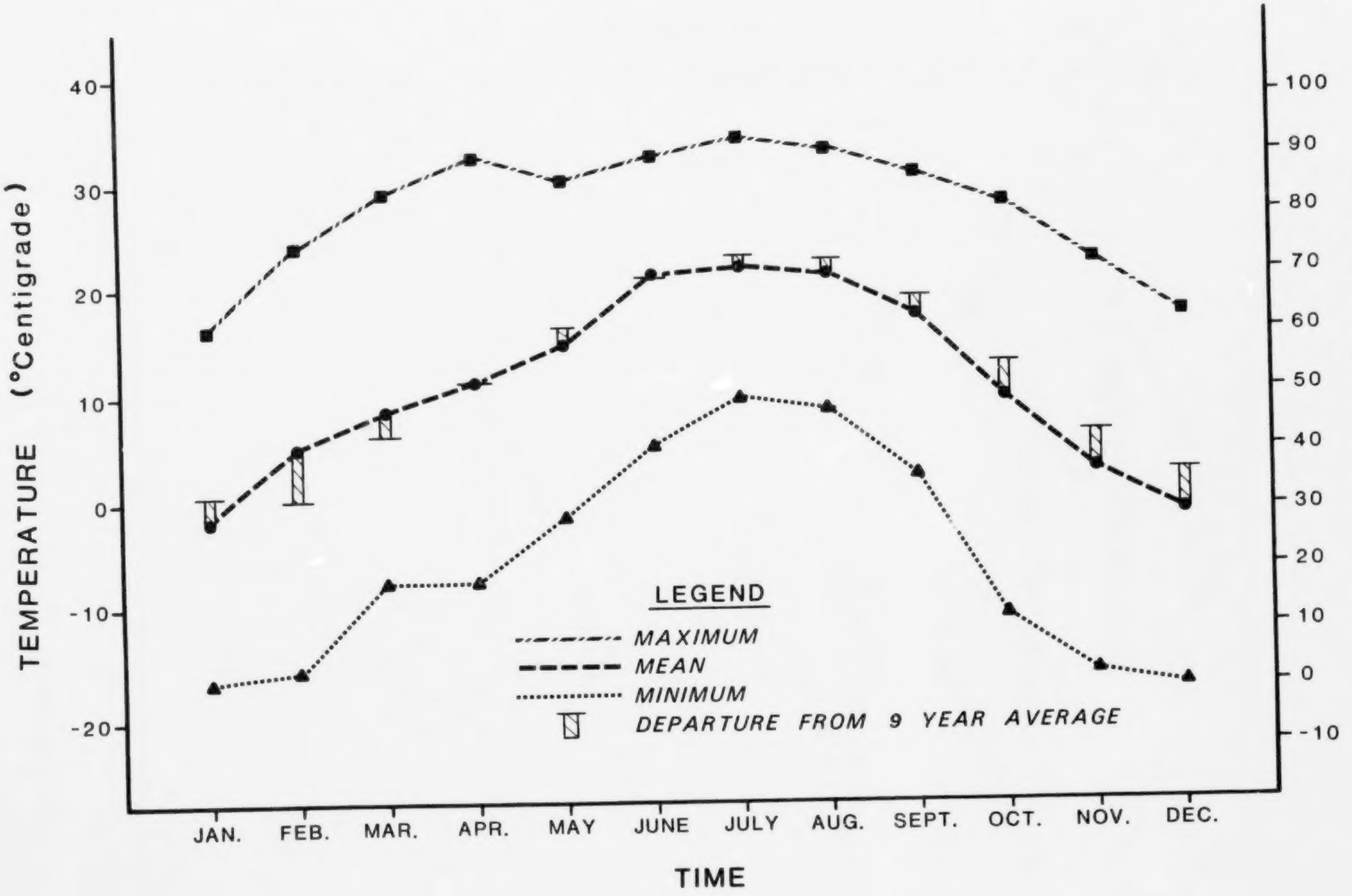


Figure 27. Temperature records in 1976 by month for mine site IA.

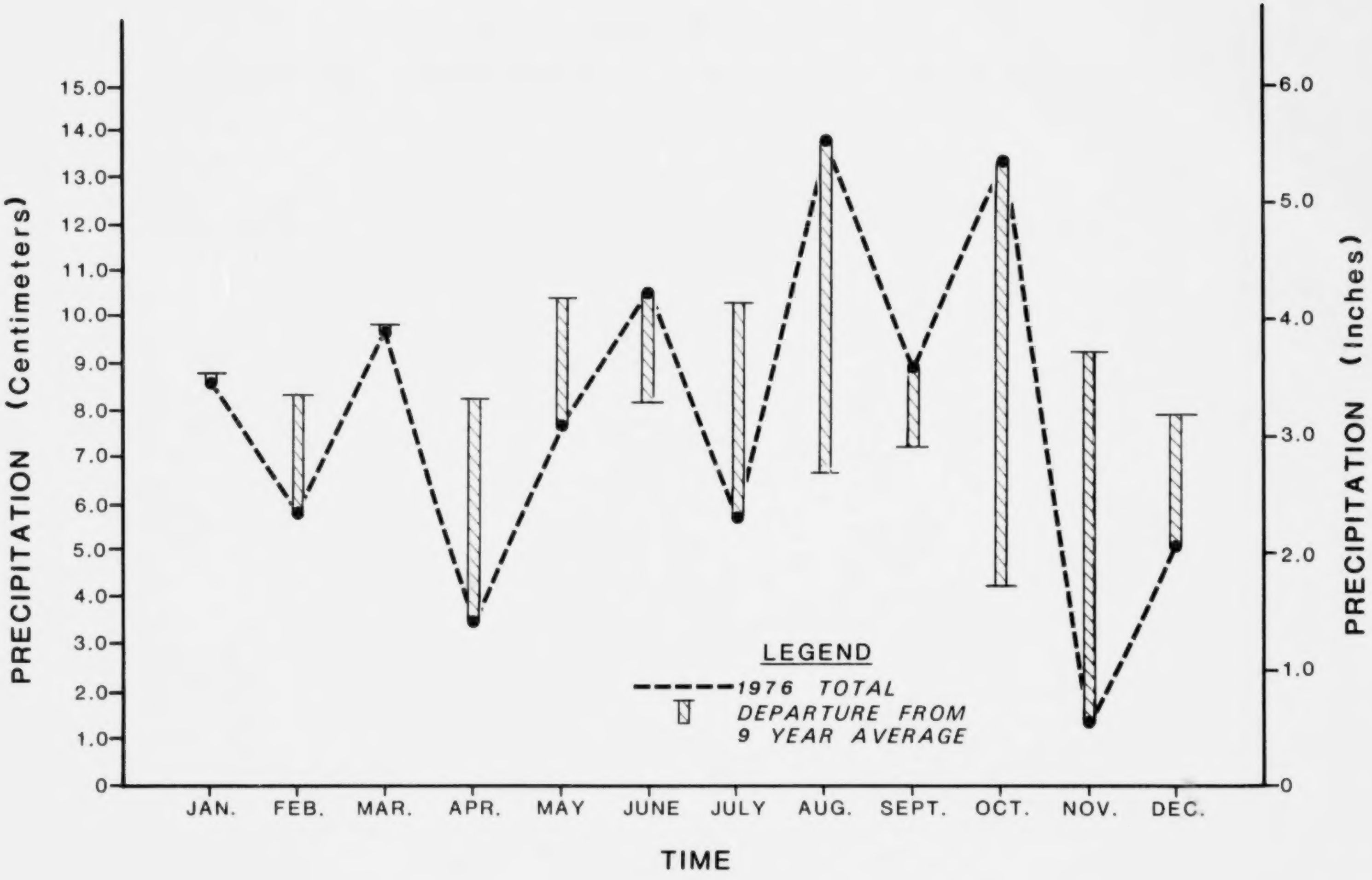


Figure 28. Total precipitation in 1976 by month for mine site IA.

TABLE 33. EQUIPMENT USED AT MINE SITE IA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loaders				
Dart D600	3	12 yd	2	Good
Cat 992	1	10 yd	3	Good
Cat 988	2	8 yd	5	Good
Huff 400	1	10 yd	2	Good
Trucks (off-road)				
Mack Unit Haul	12	–	2	Good
Mack Unit Haul	3	100 T	2	Good
International Payhaulers	8	50 T	2	Good
Dozers				
Cat D-9	5	–	Varies	Varies
Cat D-8	9	–	Varies	Varies
Cat D-6	1	–	–	–
Cat D-120	2	–	Varies	Varies
Shovels				
Marion	3	–	Varies	Varies
Marion	2	–	–	–
O&K Shovel RH60 (German)	2	–	1	Varies
Drills				
Robbins RT6C	1	9"	Varies	Varies
Robbins RRII	3	9"	Varies	Varies
Horizontal		10 5/8"	Varies	Varies
Airtrack (truck mtd)	1	2"	Varies	Varies
Coal Haulers				
Goodbary	4	–	Varies	Varies
Chevrolet C90	5	25 T	Varies	Varies
Miscellaneous				
Water truck	2	10,000 gal.	–	–
Cat Scraper 14F	1	–	–	–
Cat Scraper 14G	2	–	–	–

Explosive load – 33 kg (72 lbs.)

- Overburden – Seven benches compose a total 93 m (305 ft.) of principally sandstone and shale
- Spoil transport – Shovels and trucks used for transport – less than one mile to deposition sites
- Coal removal
  Production – 0.9-1.4 million metric (1-1.5 million short) tons/year
  Method – Shovels, loaders and large haul trucks
  Haulage – Approximately two miles from pit to prep plant
  Market – Utility steam

Reclamation – To date no reclamation efforts have been initiated.

Head-of-Hollow Fill

Fill Description
- Volume – 26 million cubic m (34 million cubic yds.)
- Slope – Sidewalls 35°-38°; 5° at toe of hollow
- Spoil haulage distance – 1.6 km (1 mile)

Site Preparation
- Sediment ponds
  Location – Two on site; one at toe of advancing fill, another about 300 m (1,000 ft.) from proposed final toe
  Type – First pond – excavation silt; second pond – rock dam
- Erosion control
- Clearing and grubbing
  Type vegetation – Second-third growth Mesophytic forest
  Removal method – Cut and grubbed
  Disposition – Windrowed at base of fill

Fill Construction
- Underdrainage system – Fractured sandstone and shale french drain formed by natural segregation
- Spoil placement – Free-dumped
- Lift design – One large lift
- Final fill form
  Slope – Maximum 20°

Reclamation – Reclamation efforts have not as yet been initiated at this site.

Water Quality
- Periodic samples – See Table 34
- Weather condition during collection – See Table 35

TABLE 34. WATER QUALITY AT MINE SITE
IA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
EFFLUENT	April	6.5	24	2	2.0	250	85	1260	275	87	103	2.5	1.0	<.01	.12	<.01	.02	.02	1650
	June	6.9	34	0	1.8	80	265	590	50	80	39	2.9	.8	<.01	.20	<.01	.08	<.01	700
	August	7.2	74	0	.45	10	250	676	6	55	43	3.0	<.1	<.01	.12	<.01	.06	<.01	870
	October	7.2	48	0	.79	85	160	480	60	50	44	1.5	.2	<.01	.14	<.01	<.03	.74	610
	November	7.4	80	0	3.6	15	180	466	18	107	43	2.8	1.9	<.01	.24	<.01	.06	.05	600
	AVERAGE	–	52	< 1	1.73	88	188	694	82	86	54	2.5	.8	<.01	.16	<.01	.06	< .17	886
INFLUENT	August	6.9	80	0	.44	10	250	738	22	57	45	3.2	.3	<.01	.04	<.01	.07	<.01	925
	November	7.1	112	0	.67	370	220	793	291	107	39	2.2	.3	<.01	.24	<.01	.05	.77	710
	AVERAGE	–	96	0	.56	190	235	766	156	82	42	2.7	.3	≤.01	.14	≤.01	.06	≤ .39	818

Note: All units mg/l except where noted.

TABLE 35. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE IA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*APRIL*	8 (46)	32 (90)	1.14 (0.45)	20	1.52 (0.60)	60	73.86 (29.08)	41	13.7 (8.5)	27	Sunny, hot and humid
	JUNE	14 (58)	24 (76)	0.56 (0.22)	1	2.03 (0.80)	100	73.96 (29.12)	87	5.2 (3.2)	35	Warm, humid and overcast
	AUGUST	16 (61)	31 (87)	0	7	0.13 (0.05)	50	74.11 (29.18)	51	4.8 (30)	6	Hot, humid and hazy
	OCTOBER	2 (35)	18 (64)	0	2	4.37 (1.72)	50	74.47 (29.32)	50	3.1 (1.9)	11	Clear and cool
	NOVEMBER	-6 (22)	12 (54)	0	4	0.05 (0.02)	90	74.50 (29.33)	40	14.0 (8.7)	30	Fair and cold
1977	*APRIL*	7 (44)	28 (82)	0	12	0.91 (0.36)	100	74.19 (29.21)	34	2.9 (1.8)	7	Hot and overcast

MINE SITE KA

Physical Description

Topography
- Location – Cumberland Plateau, eastern Kentucky
- Terrain – Steep narrow erosion valleys and mountains
- Elevation – 335 m (1,100 ft.) to 472 m (1,550 ft.)
- Slope – 31° on sidewalls, 8° on toe of hollow
- Area – 4 Ha (9 A)
- Vegetation – Third or fourth generation oak-maple

Climatology
- Local storms – Intense thunderstorms average 45 days/year
- Runoff – 41 cm (16 in.)/year
- Erosion potential – Severe
- Annual precipitation – 122 cm (48 in.)
- Local temperature – See Figure 29
- Local precipitation – See Figure 30

Geology
- Strata – Sandstone, shale, siltstone and fire clay
- Age of formation – Lower-Middle Pennsylvanian
- Coal seams – Hazard #7, #8, and #9
- Coal quality (average)

Coal quality (average)	#7	#8	#9
BTU –	11,500	10,500	11,500
Sulfur –	0.8%	0.6-0.8%	0.8-1.3%
Ash –	14%	18-20%	14%
Moisture –	6%	5%	6%

Pedology
- Major soil association – Jefferson-Shelocta (76%)
- Description – Deep, well drained, formed from loamy colluvium from acid sandstone, siltstone and shale
- Minor soils – Rigley, Dekalb, Lily, Wernock, Allegheny, Pope, Stendal and Latham

Mining Technique: Contour Strip

Operations
- Area – 4 Ha (9 A)
- Employees – 24
- Work schedule – Two 10-hour shifts/day, five days weekly
- Coal series – Upper Pottsville

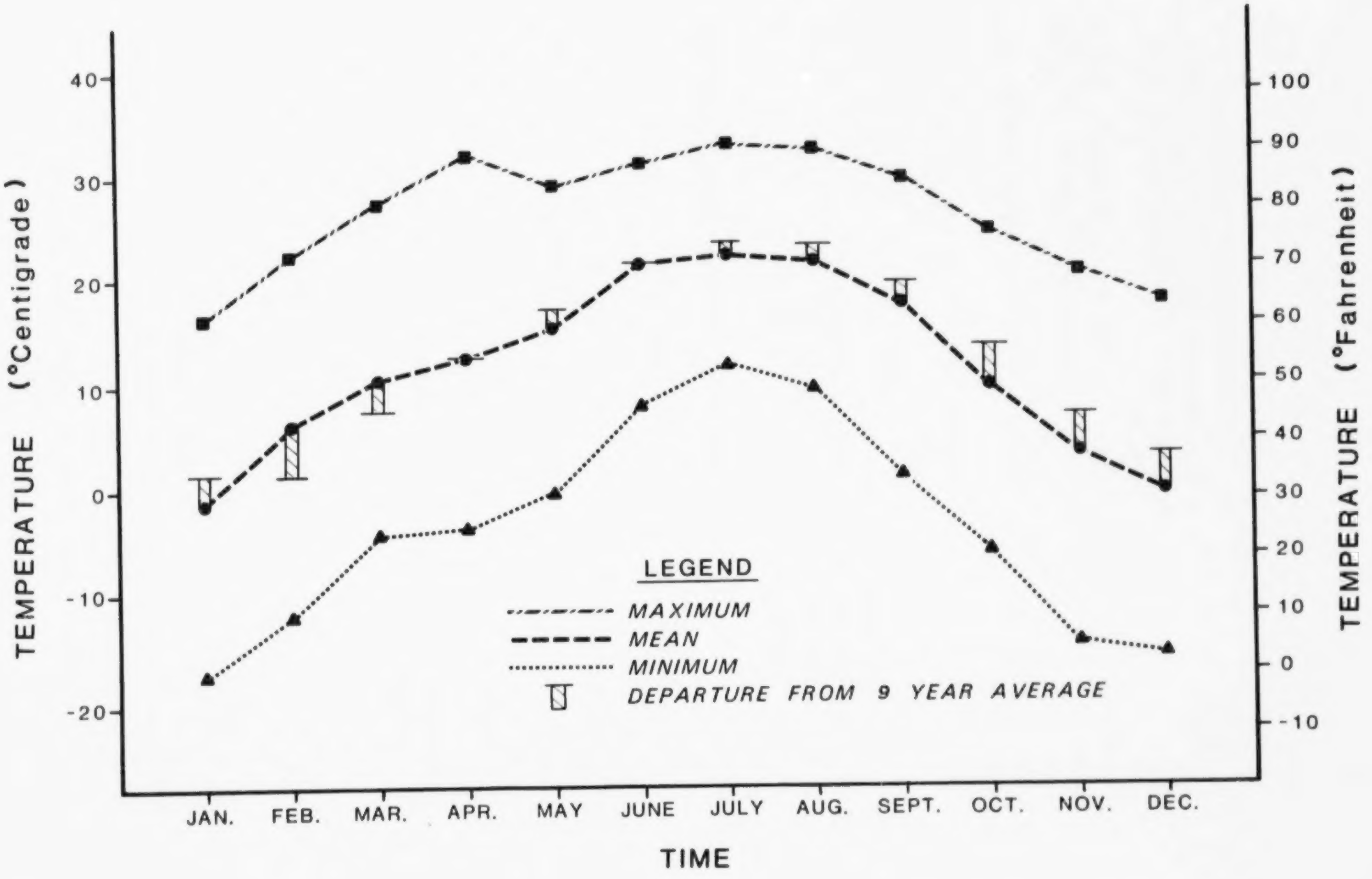


Figure 29. Temperature records in 1976 by month for mine site KA.

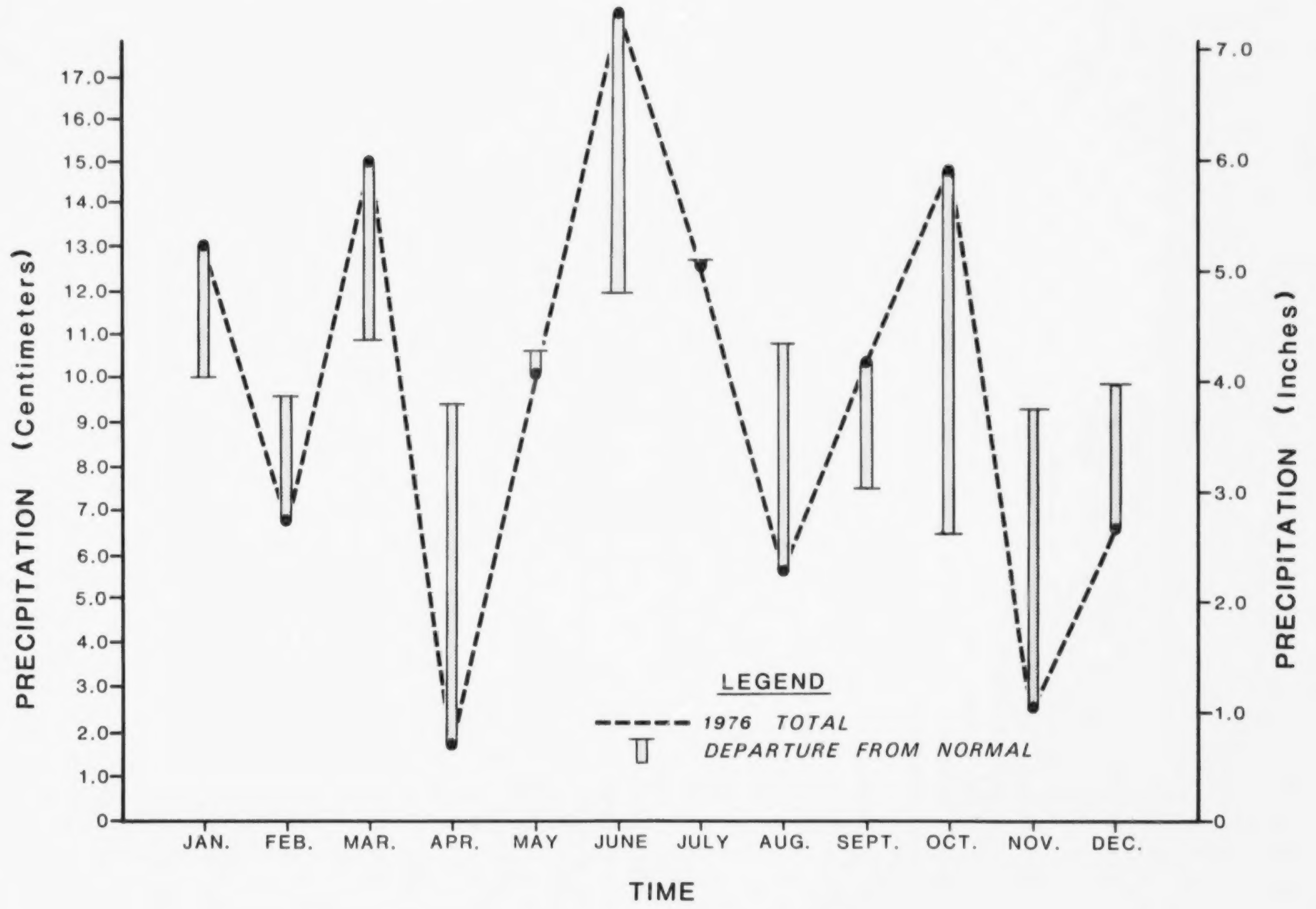


Figure 30. Total precipitation in 1976 by month for mine site KA.

Equipment – See Table 36

Mining Techniques

- Exploration – Stratigraphic cores
- Erosion control – Diversion ditches toward sediment pond, as well as a box cut around mined area
- Drilling and blasting
  - Drill depth – 7 m (24 ft.)
  - Drill hole spacing – 2.4 m (8 ft.) centers
  - Drill hole size – 17 cm (6 3/4 in.)
  - Type explosive – ANFO
  - Type detonation – Electric cap and delays
  - Detonation pattern – Simultaneous rows
  - Explosive load – 57 kg (125 lbs.)/hole (average) with some chambering
- Overburden – Acidic
- Spoil transport – Front-end loaders – 35 ton trucks
- Coal removal
  - Production – 272,000 metric (300,000 short) tons/year
  - Method – Front-end loaders – 25 ton coal haulers
  - Haulage – 3.2 km (2 miles) to utility company
  - Market – Utility steam

Reclamation

- Regrading – Cover material graded back into strip bench by bulldozer
- Revegetation
  - Area – 4 Ha (9 A)
  - Method – Hydroseeded
  - Fertilizer – 20-40-0
  - Mulch – 1682 to 3361 kg/Ha (1,500 to 3,000 lbs./A) wood fiber
- Trees – 1976 pine and locust trees/Ha (800/A) hand planted
- Intended land use – Wildlife habitat
- Seed mixture – Kentucky 31 fescue – 27 kg/Ha (25 lbs./A)
  - Ryegrass – 17 kg/Ha (15 lbs./A)
  - Lespedeza – 35 kg/Ha (30 lbs./A)
  - Crownvetch – 35 kg/Ha (30 lbs./A)

Head-of-Hollow Fill

Fill Description

- Volume – 131,000 cubic m (171,000 cubic yds.)
- Slope – 21° on sidewalls; 5° at toe

TABLE 36. EQUIPMENT USED AT MINE SITE KA

Equipment	No. of Pieces	Capacity	Age (Years)	Condition
Front-End Loaders				
Cat 988	1	5½ yd^3	1	Good
Cat 988	1	5½ yd^3	3	Good
Michigan 475	1	9 yd^3	6	Fair
Truck (off-road)				
Euclid R35	2	35 T	1	Good
Dozers				
Cat D-9	3	14'	2	Good
Cat D-8	1	14'	6	Poor
Drills				
Chicago Pneumatic 650	1	6 3/4"	7	Fair
Robbins RD 16	1	6 3/4"	2	Fair
Grader				
Cat 12	1	12'	1	Good
Trucks (coal haulers)				
Mack 25 T	5	25 T		Good

- Spoil haulage distance – Less than 0.8 km (½ mile)

Site Preparation

- Sediment pond
  - Location – Approximately 15 m (50 ft.) below toe
  - Type – Earthen dam with standpipe
  - Size – Surface area 0.15 Ha (0.38 A); capacity 987 cubic m (0.8 ac.-ft.)
- Erosion control – Diversion ditches directed toward sediment pond, and windrowed check dam
- Clearing and grubbing
  - Type vegetation – Oak-maple forest
  - Removal method – Cut and grubbed with bulldozers
  - Disposition – Windrowed

Fill Construction

- Underdrainage system – Fractural sandstone french drain formed by natural segregation

- Spoil placement – Free dumped from head of fill
- Lift design – Two lifts – first, 27 m above toe of fill; second, 12 m above toe
- Final fill form
  - Slope – Head of fill 1 to 5°, maximum outslope 20°
  - Area – 3 Ha (7.7 A)

Reclamation

- Regrading – D-9 dozer, cleat tracks left remaining as seed traps
- Revegetation
  - Area – 3 Ha (7.7 A)
  - Fertilizer – 20-40-0
  - Mulch – 1682 to 3361 kg/Ha (1,500 to 3,000 lbs./A) wood fiber
- Seed mixture – Kentucky 31 fescue – 27 kg/Ha (25 lbs./A)
  - – Ryegrass – 17 kg/Ha (15 lbs./A)
  - – Serecia Lespedeza – 35 kg/Ha (30 lbs./A)
  - – Crownvetch – 35 kg/Ha (30 lbs./A)

Water Quality

- Periodic samples – See Table 37
- Weather condition during collection – See Table 38

TABLE 37. WATER QUALITY AT MINE SITE
KA'S SEDIMENT POND

SOURCE	MONTH	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (µmhos/cm)
EFFLUENT	April	7.4	52	0	.48	70	70	240	65	30	20	.02	1.2	<.01	.01	<.01	<.03	.15	275
	June	[illegible]	70	0	3.0	150	300	625	150	59	39	2.5	1.5	<.01	.10	<.01	<.03	<.01	650
	August	7.5	284	2	1.7	5	70	502	8	58	51	18.0	<.1	<.01	.01	<.01	<.03	<.01	720
	October	7.5	94	0	1.2	30	240	490	20	63	61	2.4	.1	<.01	.16	<.01	<.03	1.2	610
	November	7.5	228	6	4.4	<5	280	688	4	120	96	71.0	<.1	<.01	.02	<.01	<.03	<.01	920
	AVERAGE	-	146	<2	2.2	52	192	509	49	66	53	18.8	<.6	<.05	.06	<.05	<.03	<.28	635

Note: All units mg/l except where noted.

TABLE 38. CLIMATOLOGICAL CONDITIONS DURING WATER QUALITY SAMPLING PERIODS AT MINE SITE KA

YEAR	MONTHS	TEMPERATURE °C (°F)		PREC. DURING DAY OF VISIT CM (IN)	PRECIPITATION PRIOR TO SITE VISIT		DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		DAILY MIN.	*DAILY MAX.*		*NO. DAYS*	*AMOUNT CM (IN)*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*APRIL*	9 (49)	31 (87)	0	1	1.25 (0.49)	20	73.43 (28.91)	37	4.8 (3.0)	26	Dry, Hot, Sunny
	JUNE	11 (52)	26 (79)	0	7	0.43 (0.17)	100	73.74 (29.03)	60	2.1 (1.3)	25	Humid and overcast
	AUGUST	18 (64)	30 (86)	0	10	0.25 (0.10)	50	73.79 (29.05)	55	1.9 (1.2)	2	Warm, humid, partially overcast
	OCTOBER	3 (38)	18 (64)	0	3	0.13 (0.05)	0	74.14 (29.19)	59	0.5 (0.3)	31	Clear and sunny
	NOVEMBER	-3 (26)	18 (64)	0	8	0.30 (0.12)	20	73.46 (28.92)	49	18.5 (11.5)	25	Clear, sunny and cold
1977	*APRIL*	11 (52)	28 (83)	0	14	4.95 (1.95)	90	73.84 (29.07)	52	1.3 (0.8)	18	Hot and overcast

SECTION 7

DISCUSSION OF STUDY FINDINGS

Although all mine sites were operated in accordance with current rules, regulations and guidelines for their respective states, the following discussion and Tables 39, 40, 41, and 42 illustrate some of the problems associated with various mining procedures and site specific physical conditions. Illustrations are presented to show concepts and are not necessarily from the mine sites studied.

MOUNTAINTOP REMOVAL

The mountaintop removal technique was developed for total resource recovery, thus eliminating wasted coal trapped under an "applecore" (Figure 31). Total resource recovery results in a flat mountaintop area with increased land use potential (Figure 32).

After mining permits have been granted for the site, sediment control structures are placed in each watershed disturbed by the mining operation. The most widely used structure is the excavated pond (Figure 33); however, a gabion dam (Figure 34) is as effective, but generally requires more labor and expense to construct.

Upon completion of these environmental safeguards, the site is prepared for mining by clearing and grubbing the area of all organic material (Figure 35). Frequently windrowed at the head of the sediment ponds (Figure 36), this vegetation acts as a filter, screening out some sediment and detritus. All water from the disturbed mining area, including haul roads, is diverted through these sediment structures.

There are many methods and types of equipment employed to remove a mountaintop. The choice depends on site specific conditions previously discussed. The most common equipment used in small to medium size mines is the front-end loader/truck combination. Figure 37 illustrates such a system in operation. As the mine size increases, large equipment becomes necessary; Figure 38 shows the power shovel/truck combination

TABLE 39. ADVANTAGES AND DISADVANTAGES OF MOUNTAINTOP REMOVAL MINING IN WEST VIRGINIA AND KENTUCKY

Site Preparation		
	Advantages	• Sediment control structures are built in each drainage basin affected by the mining prior to any land disturbance. • Storm runoff diversion ditches are constructed and maintained during the entire mining operation. • Site clearing and grubbing is accomplished just ahead of the mining.
	Disadvantages	• Large areas are affected requiring more erosion and silt controls to be utilized and maintained
Mining Operation		
	Advantages	• In Kentucky a 4.6 meter (15 foot) outcrop barrier must be maintained around the mountaintop site, which protects the surrounding environment from uncontrolled storm runoff and acid mine drainage. • Total resource recovery is accomplished with minimal adverse environmental impact. • Ultimate land use potential is significantly increased. • Final land form configuration has greater flexibility and variability. • Mountaintop removal sites offer greater potential for animal habitat enhancement and management than conventional contour strip mine sites.
	Disadvantages	• In West Virginia an outcrop barrier is not required making control of water difficult; however, all runoff by law is to drain through a sediment control structure. • Large areas are disturbed before reclamation

TABLE 39. (CONT'D.) ADVANTAGES AND DISADVANTAGES OF MOUNTAINTOP REMOVAL MINING IN WEST VIRGINIA AND KENTUCKY

begins, which increases the possibility of environmental problems.

- Dust control is difficult primarily because of land being disturbed before vegetation is accomplished.
- Occassionally a mountaintop mine site is abandoned before the total ridge is removed leaving an unsightly and sometimes environmentally disruptive "applecore".
- Numerous and/or large mountaintop removal sites could have a significant impact on the local ecology, if reclamation does not consider the alteration the mining has made to the local animal habitat.
- Extensive use of head-of-hollow fill disposal sites in conjunction with mountaintop removal to create level land (as opposed to varied reclamation schemes) could destroy the present aesthetic beauty effected by visual diversity.

TABLE 40. ADVANTAGES AND DISADVANTAGES OF WEST VIRGINIA'S HEAD-OF-HOLLOW FILL CONSTRUCTION TECHNIQUES

Site Selection	
Advantages	• Fill site by law is not to contain any wet areas or underground mine openings.
Disadvantages	• Distance from the toe of the fill to sediment pond is often excessive.
Site Preparation	
Advantages	• Reclamation laws require all vegetation to be removed from fill area. • Sediment control structures are built in each affected hollow prior to any land disturbance or mining.
Disadvantages	• Clearing and grubbing is completed for the entire fill zone even if the construction will take years to complete, leaving area prone to severe erosion. • Trees are often windrowed too close to toe of fill and are occasionally covered with spoil.
Fill Construction	
Advantages	• Placed rock core along natural dendritic system provides assured drainage of most internal waters. • Fill construction begins at the toe of the fill, which permits revegetation as lifts are completed reducing erosion potential. • Hollow fill provides an environmentally sound disposal method for excessive spoil. • Spoil is trucked to and placed in fill in restricted lifts resulting in good compaction. • Present construction criteria is directed toward assuring stability in "worst case" conditions.

TABLE 40. (CONT'D.) ADVANTAGES AND DISADVANTAGES OF WEST VIRGINIA'S HEAD-OF-HOLLOW FILL CONSTRUCTION TECHNIQUES

	• Rock core provides a nonerodible path for water diverted from the mining operation. • Fill benches interrupt surface water runoff, thereby reducing erosion potential of the steep fill outslopes. • Fill benches slope toward fill mass (3 - 5%) and core, keeping most water off outslope face. • Directing all surface water through the rock core drainage system appears to have a filtering effect, thereby limiting the suspended solids concentration of drainage entering the sediment pond. • Under most circumstances, sediment control structures effectively remove eroded solids.
Disadvantages	• Surge ponds frequently retain water causing fill instability problems. • When the rock core is elevated above level of fill bench, clogging occurs at fill/core interface resulting in erosion of fill face. • Easily weathered rock is occasionally used in the core which can cause clogging and malfunction of the drainage system. • Occassionally wet areas are found within the fill and means of drainage to the core are not provided resulting in an unstable zone in the fill. • Little effort is expended on blending the fill side walls with the undisturbed ground in the hollow which can result in severe erosion ditches. • Present construction criteria makes no provisions for other than "worst case" conditions. • Hauling all material to the active fill bench and placement in restricted lifts is tremendously expensive and is not always warranted where geologic conditions are conducive to alternate construction techniques such as side dumping. • There is no upper size limit for rock being placed in the core which can result in malfunction of the underdrain if extremely large rocks are used, particularly in the initial stages of construction.

TABLE 40. (CONT'D.) ADVANTAGES AND DISADVANTAGES OF WEST VIRGINIA'S HEAD-OF-HOLLOW FILL CONSTRUCTION TECHNIQUES

- The chimney type rock core extends to the surface of the fill restricting ultimate land use of the site.
- Directing all surface water through the fill site could result in massive failure of the unconsolidated fill mass if the rock core drainage system failed to function properly.

TABLE 41. ADVANTAGES AND DISADVANTAGES OF KENTUCKY'S HEAD-OF-HOLLOW FILL CONSTRUCTION TECHNIQUES

Site Selection	
Advantages	• The slope of the hollow at the proposed toe of fill is not to exceed 10^{o}.
Disadvantages	• Distance between toe of fill and sediment control structure is occasionally excessive.
Site Preparation	
Advantages	• All organic matter must be removed from fill area. • Sediment control structures are installed before disturbing the watershed.
Disadvantages	• Construction area around sediment pond is not always revegetated after installation resulting in an abnormally high silt load in the stream below pond. • Poor quality control in construction of rock dams causing inefficient operation of settling pond and higher solids (suspended and total) concentrations downstream.
Fill Construction	
Advantages	• Hollow fills provide an environmentally more desirable disposal method than previously used in Kentucky. • When the fill spoil is pushed down every 48 hours it is compacted and shear planes are altered; however, this causes problems in the proper formation of the underdrain system. (See Figures 8 and 9.)
Disadvantages	• The construction technique does not permit segregation of easily weatherable rock from

TABLE 41. (CONT'D.) ADVANTAGES AND DISADVANTAGES OF KENTUCKY'S HEAD-OF-HOLLOW FILL CONSTRUCTION TECHNIQUES

durable rock in the underdrain.

- If the fill is pushed down to 20° every 48 hours fine grained spoil is mixed with the large rock of the underdrain increasing clogging and inefficiency of this drain.
- Due to the magnitude of many of these operations, massive lifts can result between pushdowns, thereby seriously limiting compaction of the fill mass.
- If the spoil is not pushed down frequently, compaction is obtained only on the surface, increasing the potential of tension cracks and slides.
- All surface water runoff must pass through a sediment control structure, normally found at the toe of the fill. This in itself is good; however, water running over the unconsolidated fill causes severe erosion requiring frequent repair and regrading of these surface drainways.
- Benching of the fill outslope is generally not required. Long uninterrupted slopes are thus formed which easily erode until revegetation (which is not initiated until after fill completion) is established.

TABLE 42. AREAS OF ENVIRONMENTAL IMPACT ASSOCIATED WITH HEAD-OF-HOLLOW FILLS

CONSTRUCTION ELEMENTS		ENVIRONMENTAL PROBLEM AREAS	MAGNITUDE OF PROBLEM	SOLUTION TO THE PROBLEM	RELATIVE COST TO ELIMINATE PROBLEM①
SITE SELECTION		1. Springs or wet areas within fill zone.	Moderate	1. Pick a different hollow.	Moderate
				2. Provide secondary drains to main underdrain	
				3. Provide rock blanket	High
		2. Steep slopes at proposed fill	Severe	1. Pick a better location	Moderate
				2. Use a keyway cut at toe.	
				3. Install rock buttress at toe	
				4. Utilize thin lifts and additional compaction	
		3. Long distances between fill toe and sediment pond.	Moderate	Move pond closer to fill toe.	Moderate to High
SITE PREPARATION		1. Trees not cut and removed from within fill zone. 2. Surface organic material not removed.	Severe	Cut and windrow or burn trees.	Low
SEDIMENT POND CONSTRUCTION		1. Construction area around sediment pond not revegetated.	Moderate	Grade and seed immediately after construction of pond.	Low
		2. Poor quality control in construction of rock structures.	Severe	Closer control of rock size and placement during construction.	Moderate
FILL CONSTRUCTION	WEST VIRGINIA	1. Easily weathered rock used in core drain.	Severe	Closer supervision and rock selection.	Low to Moderate
		2. Core clogs at fill bench intercept.	Minor	Closer construction supervision.	Low
		3. Erosion between sides of fill and original ground.	Minor	Blend fill side slope into original surface.	Low
		4. Wet areas not drained into core.	Severe	Construction of lateral drains to core.	High
		5. No upper size limit on core rock.	Minor to Severe	Establish upper limit for rock size.	Low
	KENTUCKY	1. Easily weathered rock used in underdrain.	Severe	Placement of selected rock underdrain	High
		2. Fine grained spoil mixed with underdrain.	Severe	Modify current construction practices (see discussion section VII)	High
		3. Insufficient compaction of fill spoil.	Moderate to Severe ②	Modify current construction practices (see discussion section VII)	Moderate
		4. Severe surface erosion.	Moderate	1. Divert water away from fill surface.	Moderate to High
				2. Provide a non-erodable surface for water to flow across.	
		5. Rill erosion of fill face.	Minor	Reduce length of fill face by adding diversion benches.	Low

① Relative additional cost in relation to current practices

② Depending on spoil composition and intended land use

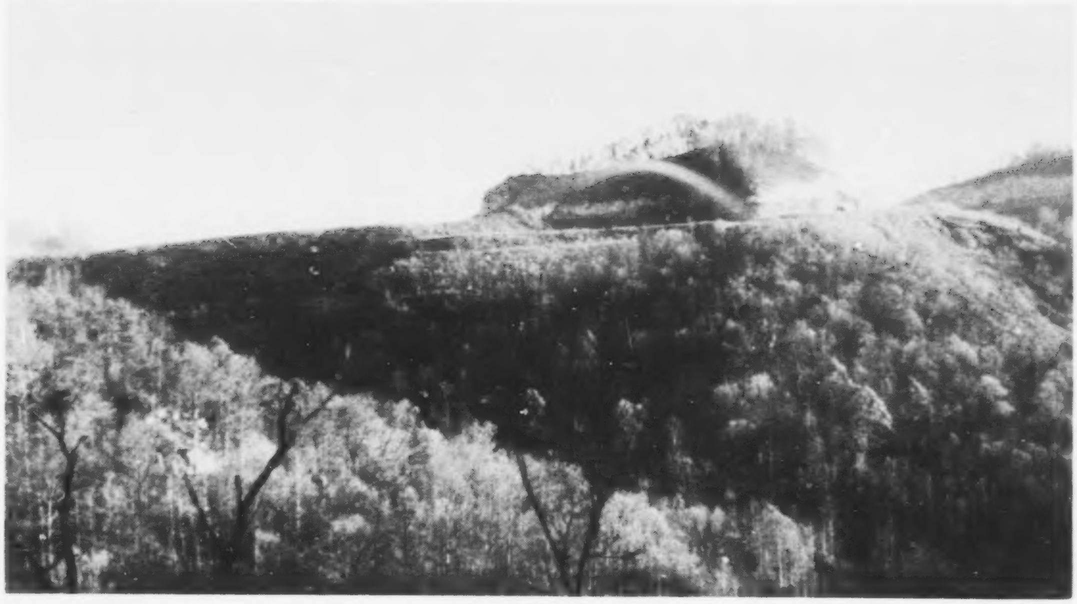


Figure 31. Applecore.

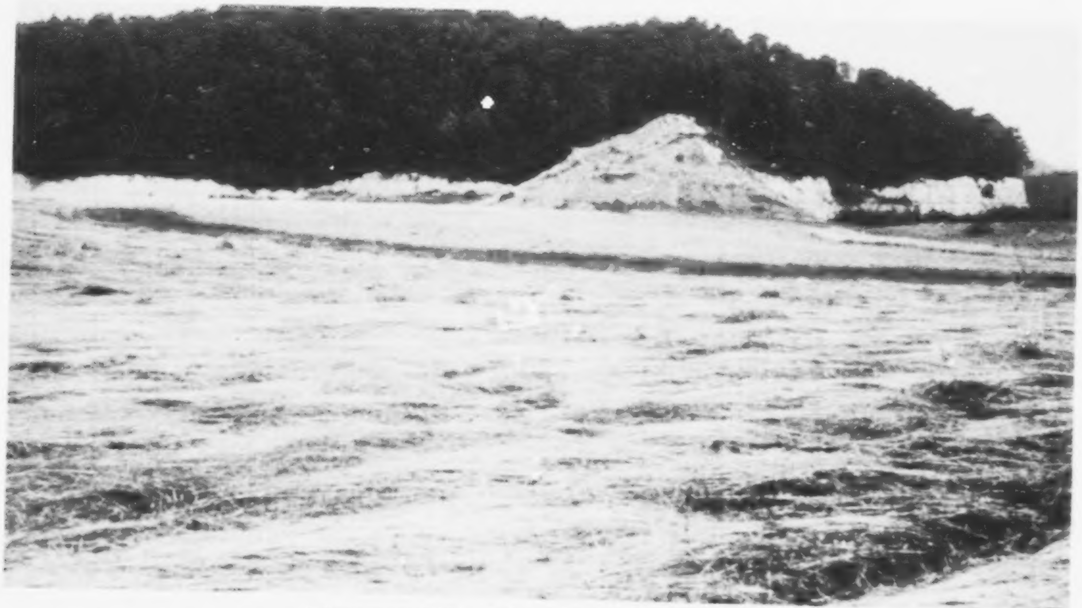


Figure 32. Mountaintop site.

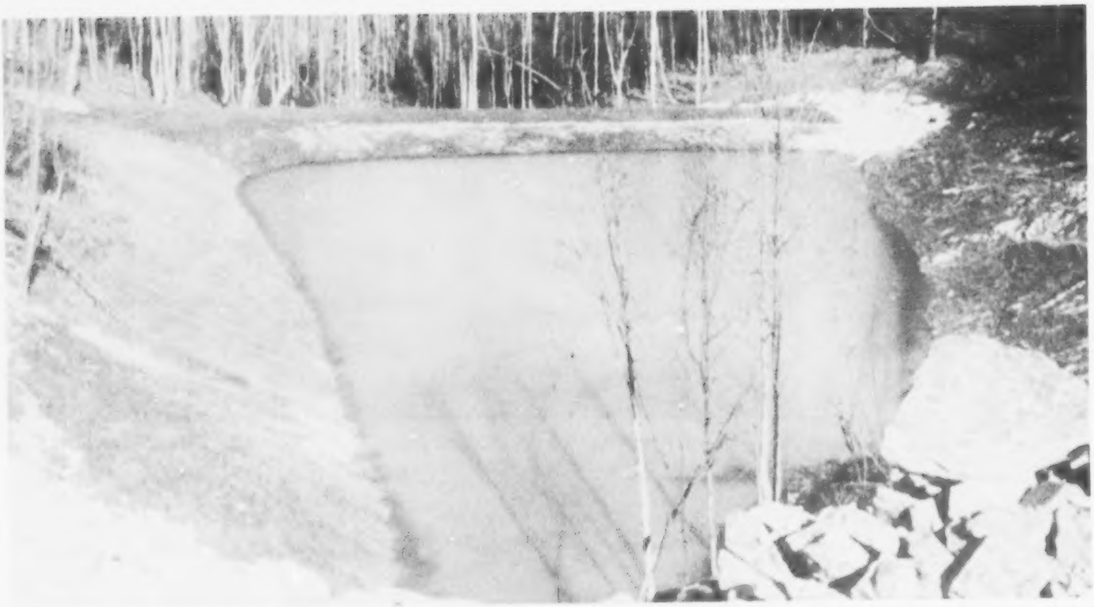


Figure 33. Excavated pond.

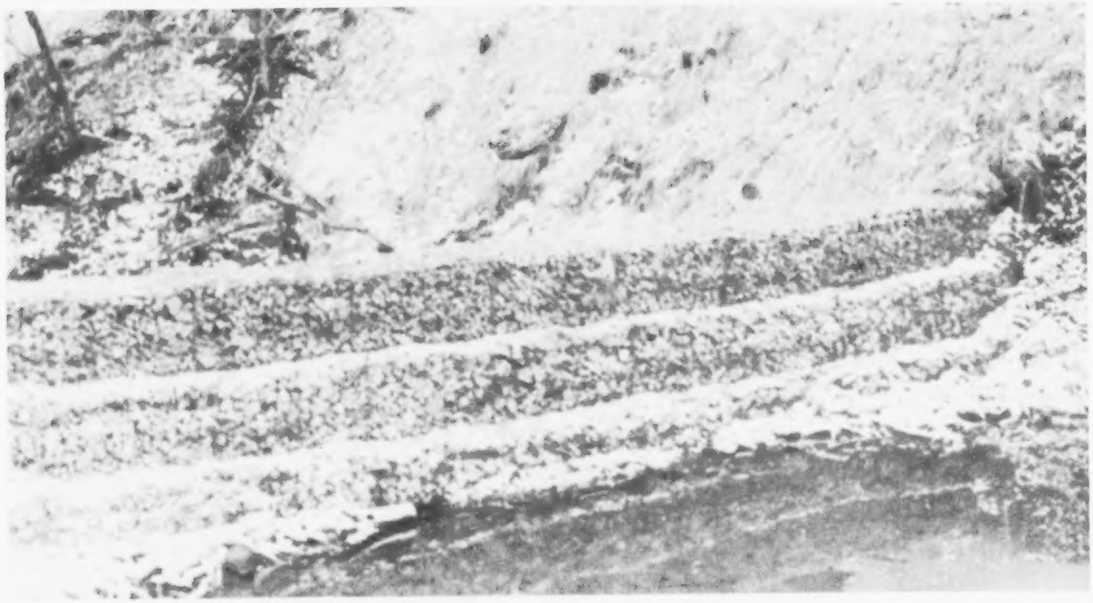


Figure 34. Gabion dam.

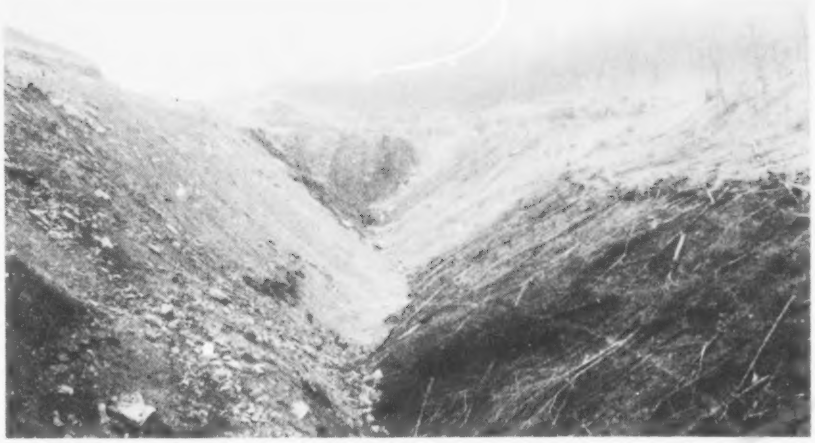


Figure 35. Clearing and grubbing a mine site.

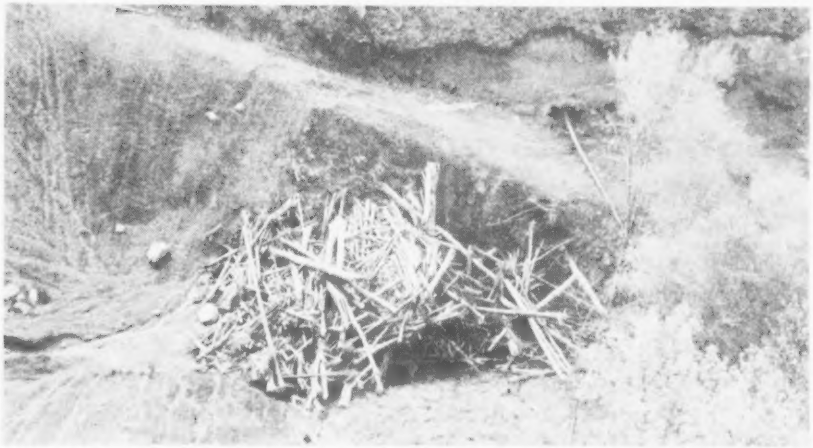


Figure 36. Windrowed vegetation.

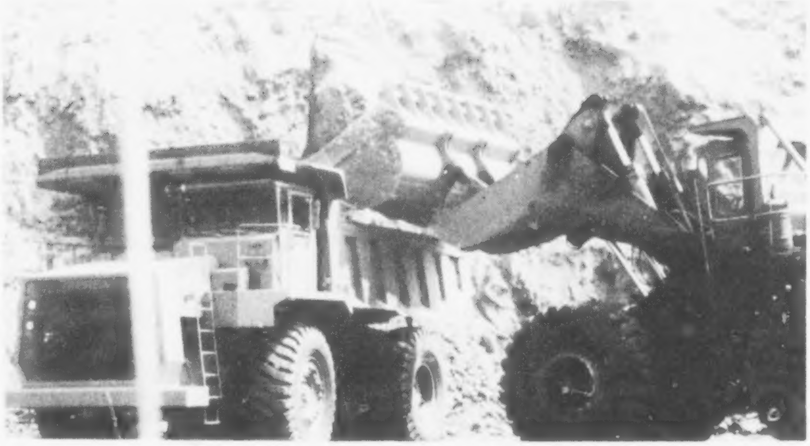


Figure 37. Loader/truck combination.

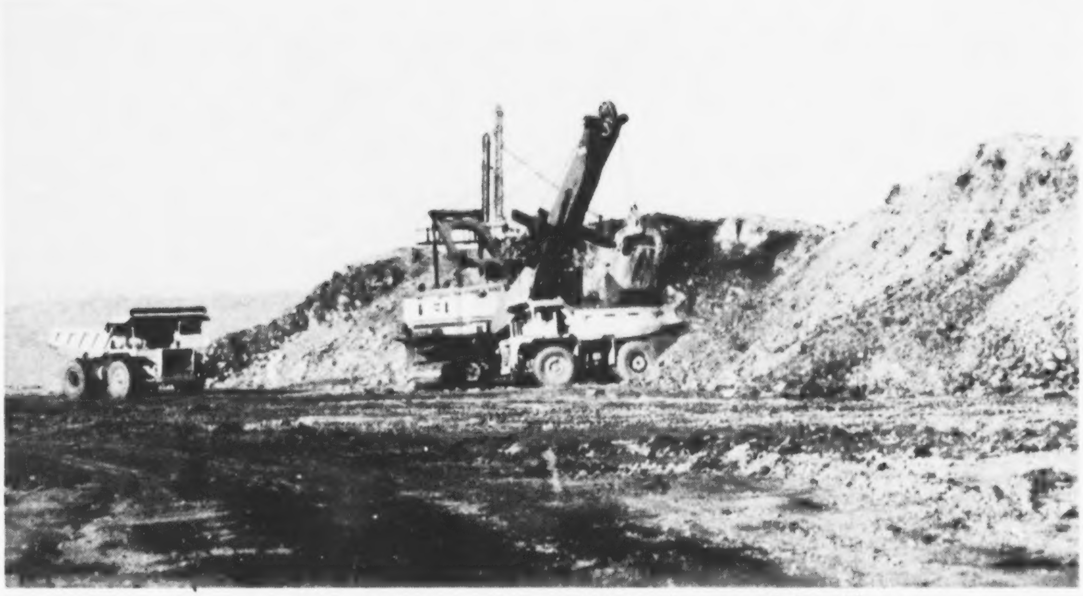


Figure 38. Power shovel/truck combination.

at work. Pan scrapers (Figure 39) are utilized in combination with some overburden removal systems provided the material is compatible. Draglines (Figure 40) are used least frequently; generally, only large multiseam mines with associated higher overburden ratios can afford the capital expenditure. Prior to any overburden removal, the immediate mining area must be drilled and blasted to reduce the consolidated substrate into particle sizes that the selected removal equipment can handle. A typical mine blast was photographed and is presented in Figure 41.

Most West Virginia and Kentucky operations work under two extremes: mud up to axles or dust knee deep. The dust presents not only an environmental problem but also one of health and safety for the miners. Dust is controlled by watering the haul roads on a regular basis (Figure 42). An extensive air quality monitoring assessment will be completed during the course of this study to more accurately define the air pollution potential of mountaintop removal mining. This information will be presented in the final report.

Frequently, the land is not owned by the company doing the mining. Reclamation is, therefore, directed towards meeting state reclamation laws and not future land use. Figure 43 shows a mountaintop lake which will be used for recreation after mining is completed; this land form was possible because the mining company owned the land and planned for its ultimate use early in the mine development.

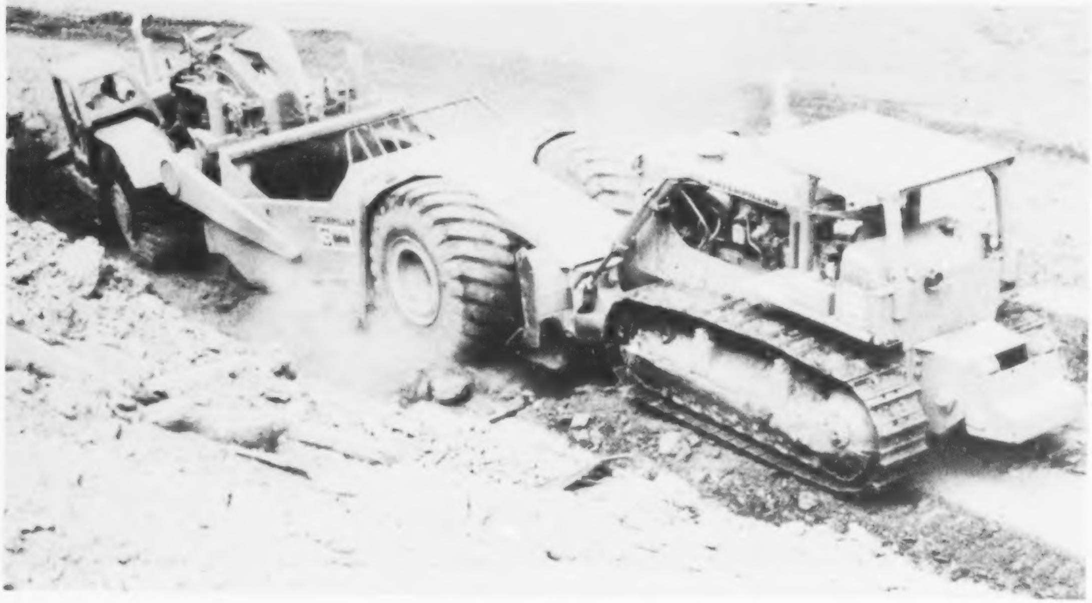


Figure 39. Pan scraper.

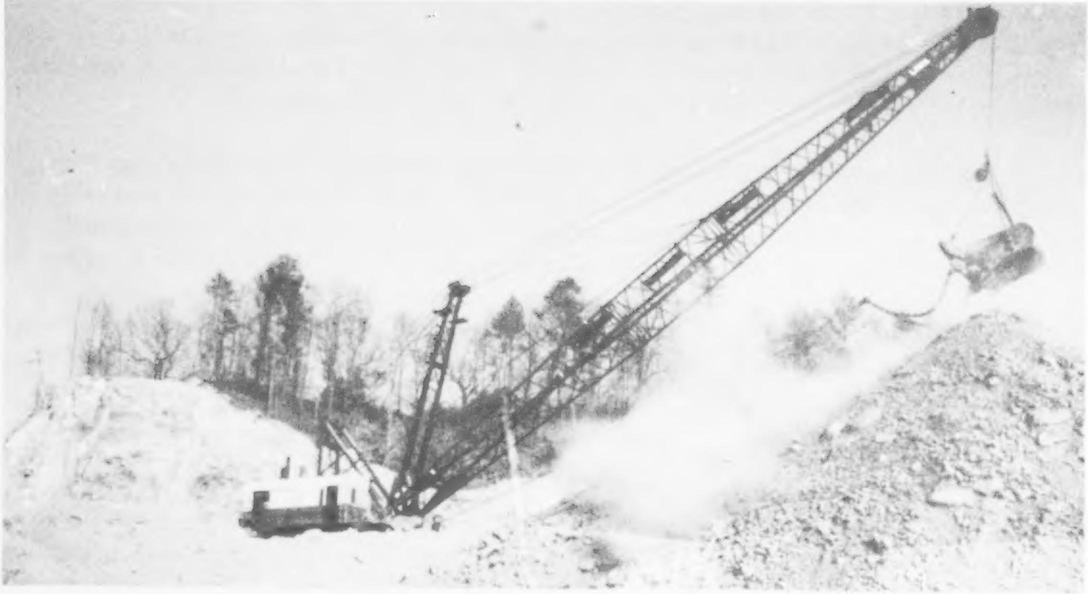


Figure 40. Dragline.

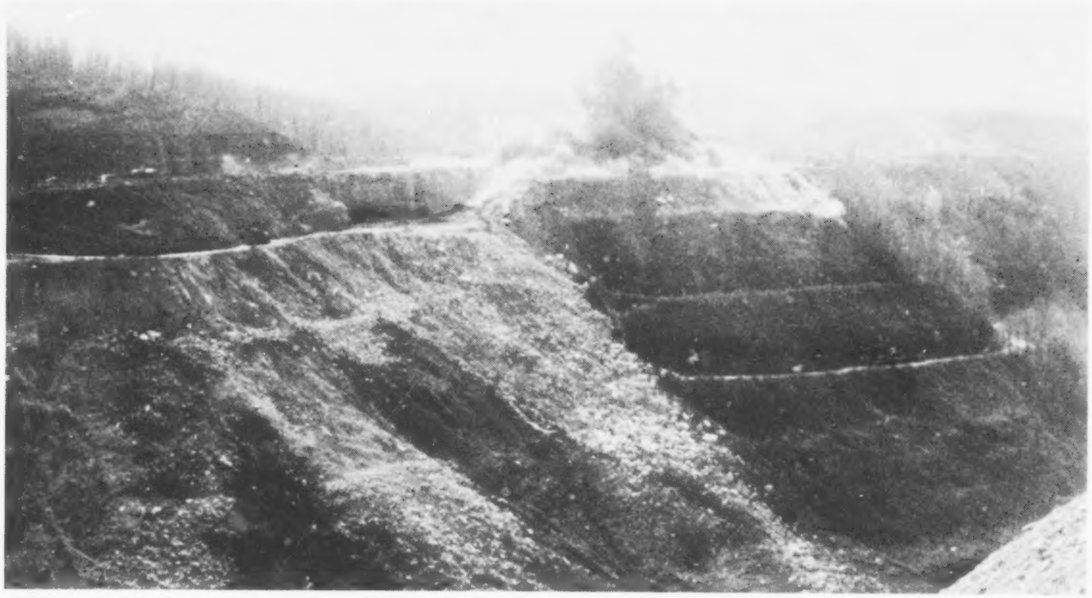


Figure 41. Typical blasting.

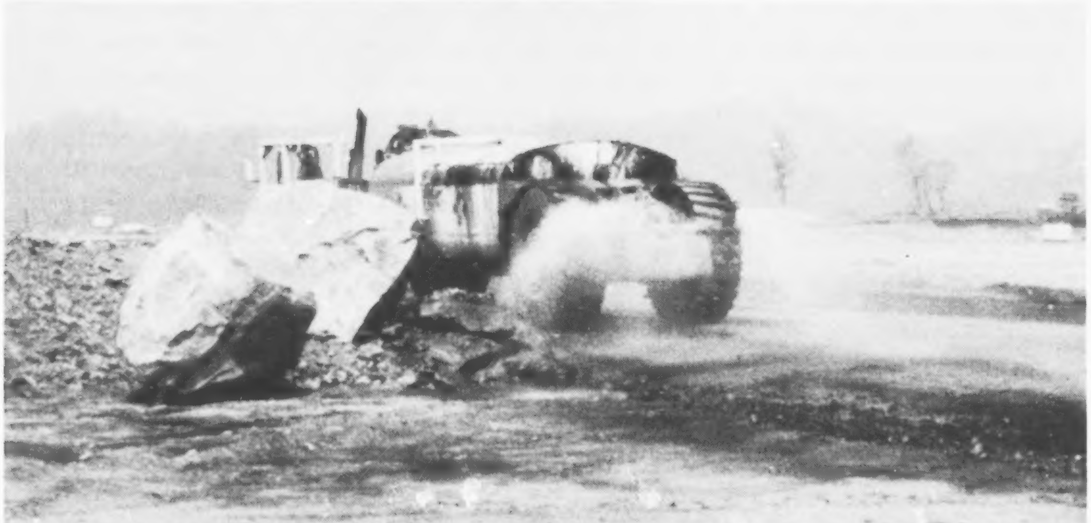


Figure 42. Dust control.

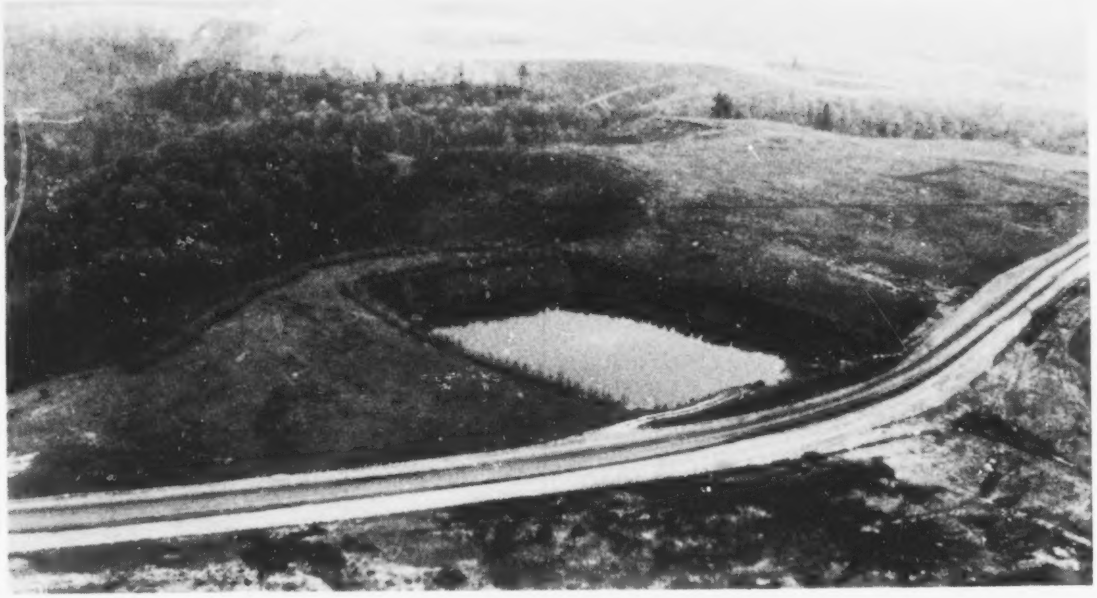


Figure 43. Mountaintop lake.

Basically, there are relatively few adverse environmental impacts associated with mountaintop removal mining, particularly when conducted in conjunction with a well designed and constructed head-of-hollow fill. However, severe impacts result when mine economics force premature closure of the operation. The most commonly employed mountaintop removal mining technique is a series of contour cuts which continue around the mountain until all overburden and coal have been removed. If carried to completion, this results in total recovery of the coal seam and reclamation of the site to a gently rolling terrain which is generally compatible with a higher land use. However, with the characteristic instability of the coal industry caused by widely fluctuating coal prices, the operation becomes increasingly susceptible to closure as overburden to coal ratios increase. Thus, many operations are abandoned before total elimination of the mountaintop is effected, leaving exposed highwalls and unmined coal. Ultimately, this results in one of two undesirable situations:

1. The creation of unsightly "applecores", or isolated mountaintops completely surrounded by highwall (Figure 31).

2. Burial of coal reserves as overburden is replaced around these "applecores" and regraded to conform to acceptable reclamation standards. These areas are then subject to later disturbance as coal economics improve and it becomes feasible to mine the untapped coal.

Modifying the mining scheme is one method of reducing the probability of premature closure, and the possibility of aesthetic or environmental degradation resulting from unreclaimed land. Under present conditions, if economics dictate mine closure, it comes at a time when the operator can least afford reclamation; consequently, reclamation quality suffers and, under extreme conditions, the site may be abandoned without reclamation. Cross-ridge mining is a type of mountaintop removal which can greatly reduce the potential of these harmful impacts. In this method, the highwall is oriented perpendicular to the long axis of the ridge. The initial cut may be through a low point in the ridge or it may begin at one end. Because mining progresses across the ridge, this method combines removal of "low cost" outcrop coal (low stripping ratio) with removal of "high cost" center-of-the-ridge coal (high stripping ratio). Consequently, each block being removed represents an average stripping ratio. Although the initial costs are higher than in conventional mountaintop removal, profits, as well as coal production, will be fairly consistent throughout the entire operation. In some cases if a high profit is required early due to high mine site preparation costs, the initial cut could be in a contour method with subsequent cuts following the cross-ridge method. As a result of the fairly uniform stripping ratio, the economics are much more stable and predictable. Thus, cross-ridge operations have more promise of going to completion, with total recovery of coal and minimal environmental impacts.

In this method, reclamation is an integral part of the mine plan and is carried out concurrently with the mining operation. As mining proceeds through the ridge, the overburden is backstacked on the bench. In this manner, the mining and reclamation operations are confined to one area, and occur simultaneously. This increases efficiency because equipment and manpower are concentrated in one area.

Another adverse environmental impact that could result from "unplanned" mountaintop removal is destruction of the aesthetic environment. Individual mine operators, unaware of other operators' mining and reclamation plans, may consciously strive to create usable level land. Unfortunately, the cumulative effects of many such operations could change the rustic beauty of the terrain into ranges of visually monotonous leveled mountaintops. It must be emphasized that, while a certain amount of leveled mountaintop land is a highly desirable reclamation goal, development potential throughout much of this area is inherently low. It makes little sense to create unlimited developable land in an area where it is not required at the expense of the innate beauty of the region. This is not to say that the area should not be mined or that the adverse environmental impacts of surface mining in these regions are insurmountable or irrevocable, for this is certainly not the case. The point here is that more emphasis should be placed on the regional or total environmental implications of a specific reclamation plan. By considering the total environment, the reclamation plan can sculpture the land to a form that harmonizes with the surrounding environment while reflecting and expressing the function or after-use of the site.

HEAD-OF-HOLLOW FILL

Utilization of the head-of-hollow fill waste disposal method enhances the value and potential land use of a reclaimed mine site. West Virginia and Kentucky have taken two rather different approaches in head-of-hollow fill construction, as previously discussed. Supporting the old proverb, "a picture is worth a thousand words", Figures 44 and 45 show a typical West Virginia and Kentucky fill, respectively.

In West Virginia, the rock core drain is continuously constructed just ahead of the fill as shown in Figure 46. Final elevation of the core with respect to the fill mass is dependent on their relative consolidation ratio, type of core material (weatherability), and the reclamation law under which it was constructed. An elevated core is pictured in Figure 47, with a depressed core shown in Figure 48.

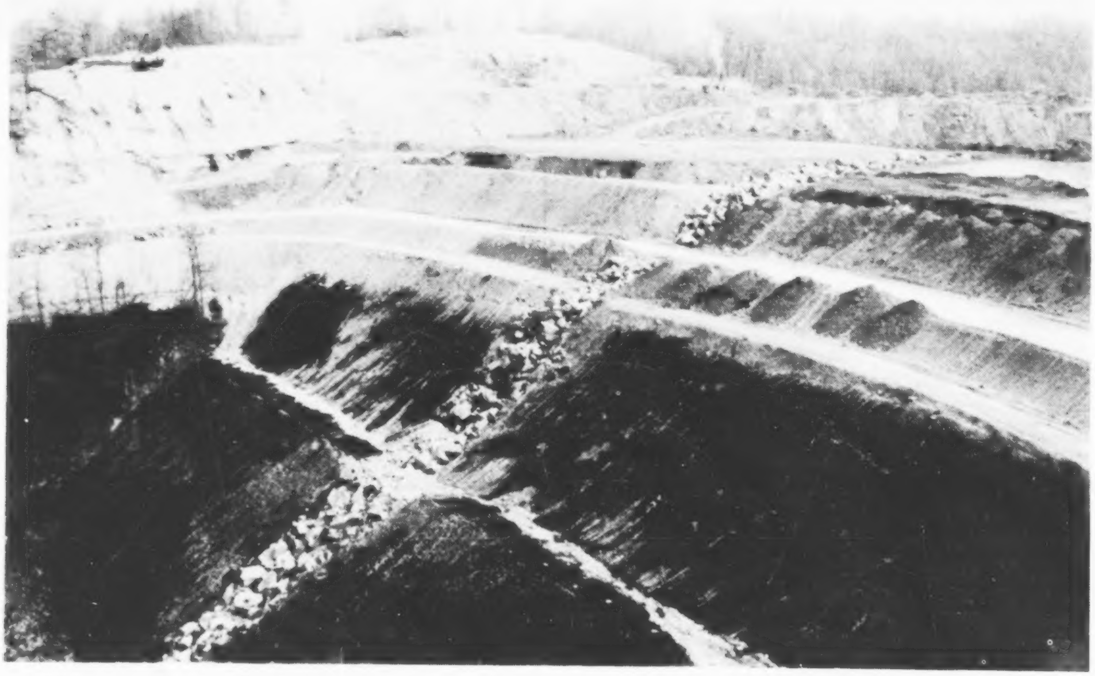


Figure 44. West Virginia hollow fill.

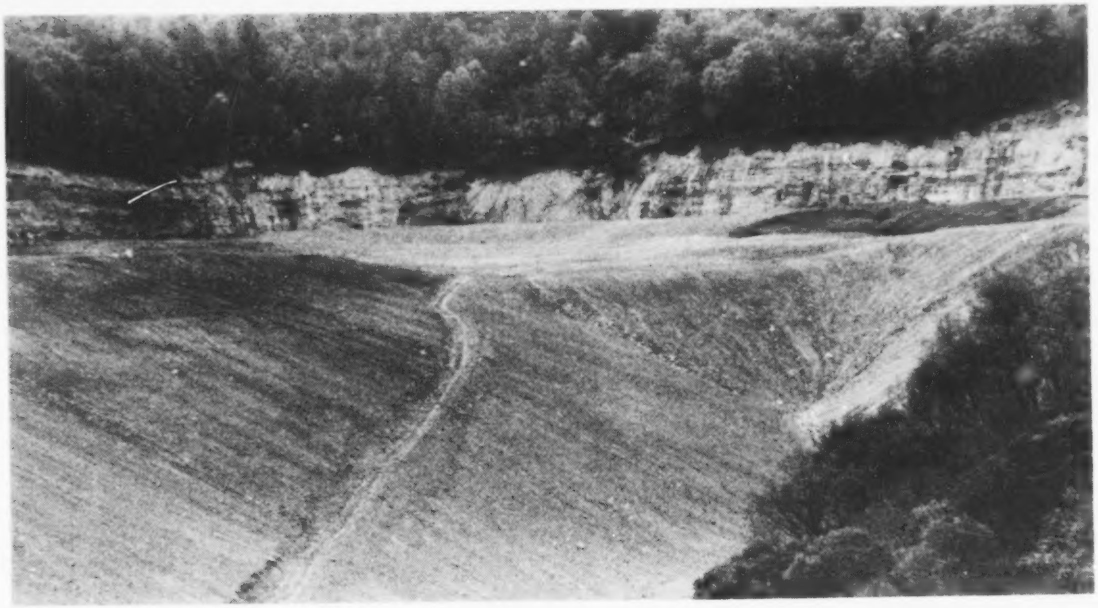


Figure 45. Kentucky hollow fill.

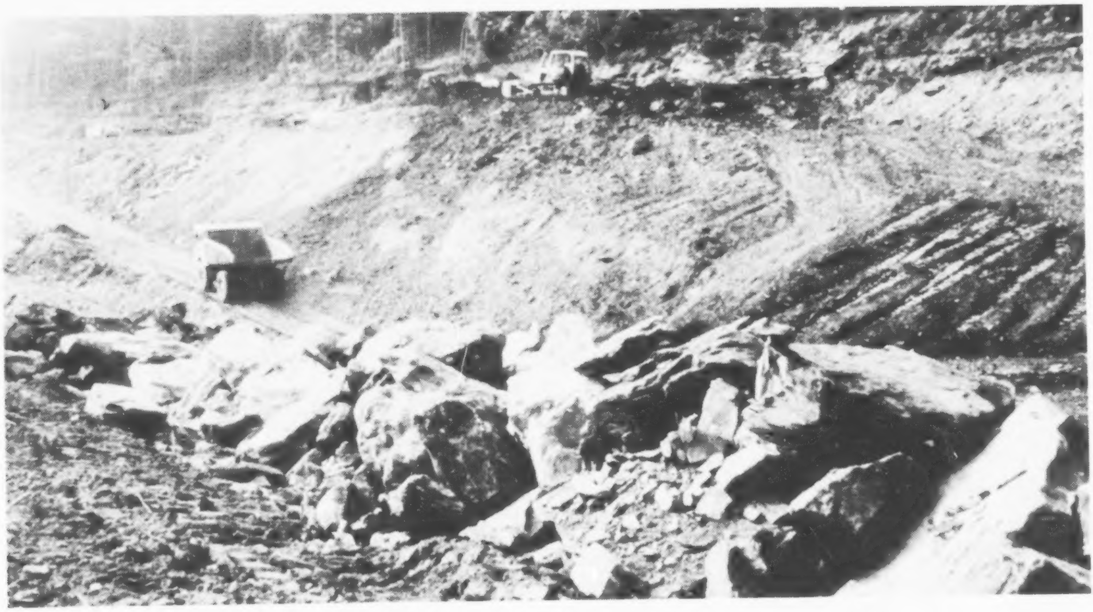


Figure 46. Rock core drain construction.

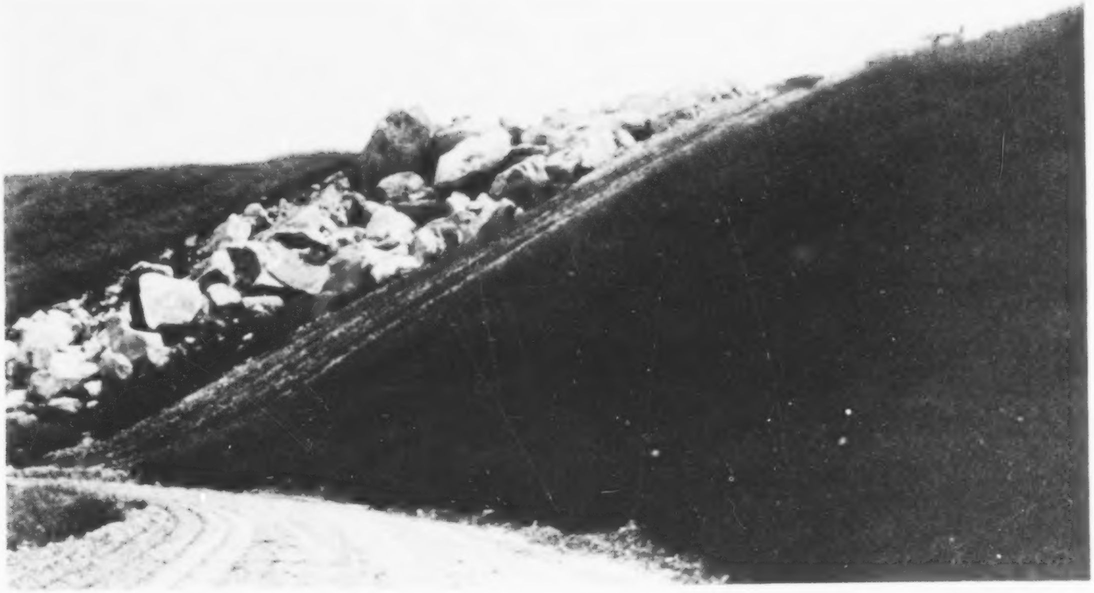


Figure 47. Elevated rock core.

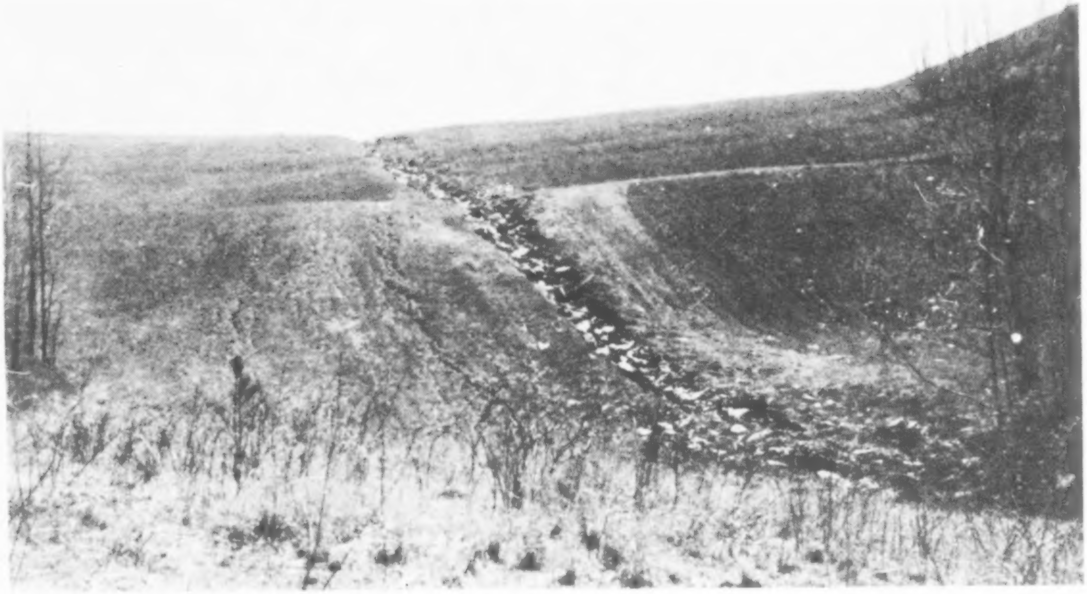


Figure 48. Depressed rock core.

Spoil in Kentucky fills is placed by side dumping or end dumping (Figure 49) from the head of the hollow. Erosion and fill stability are of great concern to the miners during construction and early stages of revegetation. During spoil deposition, the stability of a fill must be carefully monitored; generally, unstable areas will first develop tension cracks, then begin to settle as shown in Figure 50.

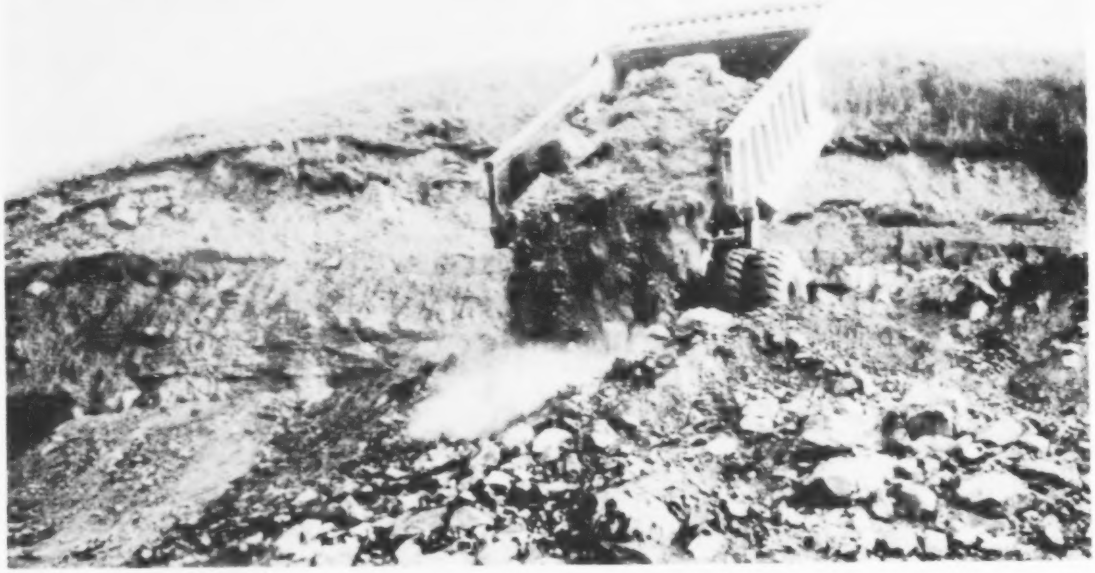


Figure 49. Kentucky fill placement by end-dumping.

The steep outslopes (26°) of West Virginia fills can be easily eroded prior to the establishment of a good vegetative cover (Figure 51). Outslopes in Kentucky fills (20°) are even more susceptible to these forces (Figure 52) than West Virginia slopes, for two basic reasons:

- long uninterrupted slopes (Figure 53)
- inability to revegetate slopes until the entire fill has been completed

A few reclamation specialists, on their own initiative, have managed to reduce erosion potential of these long slopes by cutting a narrow bench (10° downgrade) across the fill face (Figure 54). This is accomplished during the final grading prior to applying the seed mixture. Benching provides an additional benefit, making it feasible for a hydroseeder to be driven down the fill face, thus enabling the entire fill surface to be hydroseeded. This is not always possible in the steep terrain of eastern Kentucky.

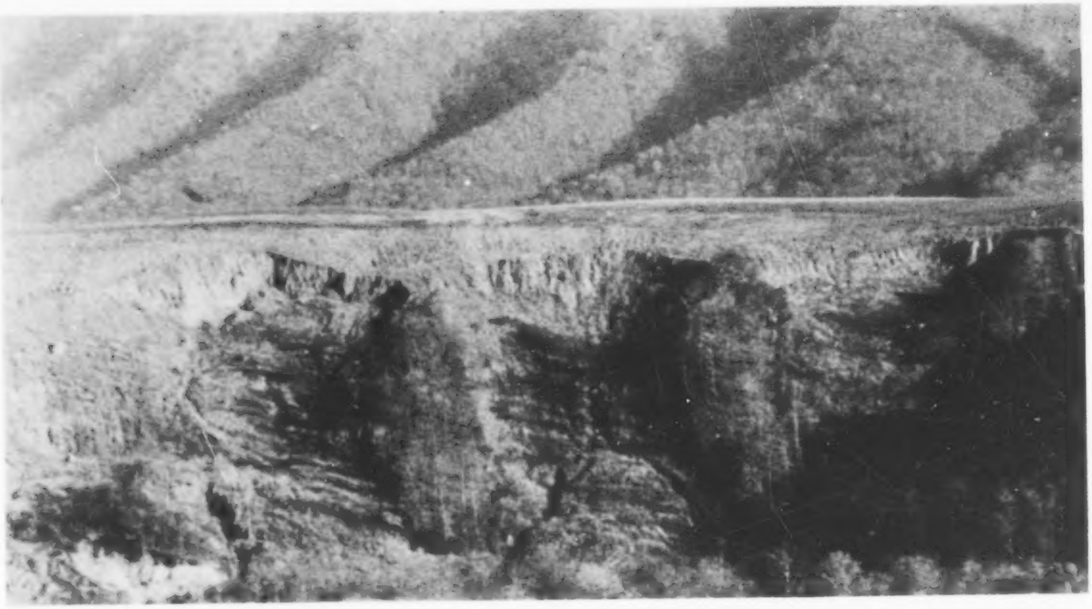


Figure 50. Slip area in hollow fill.

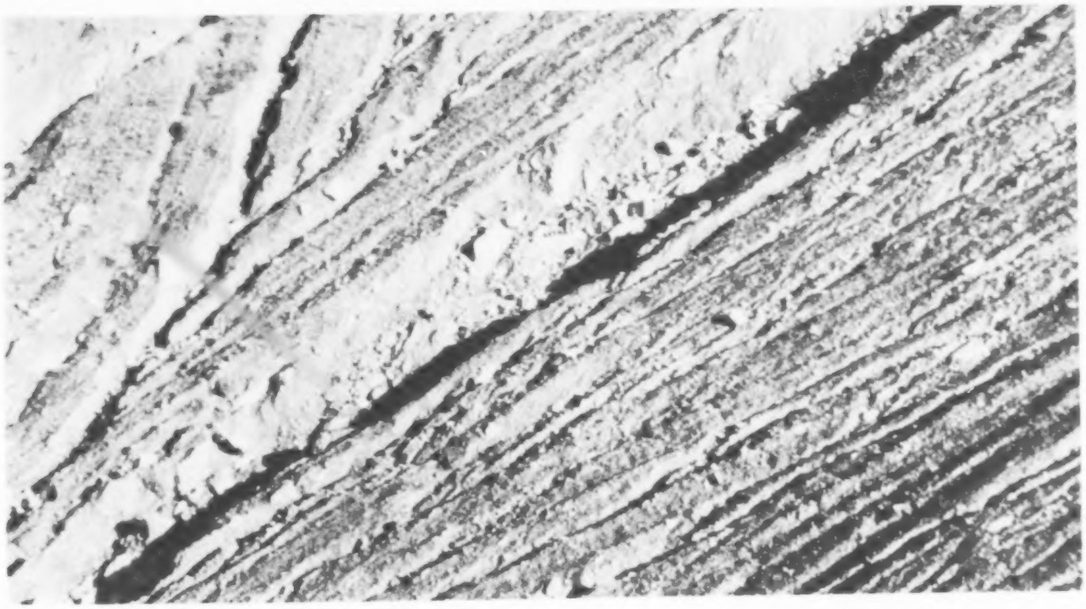


Figure 51. Erosion of outslope in West Virginia.

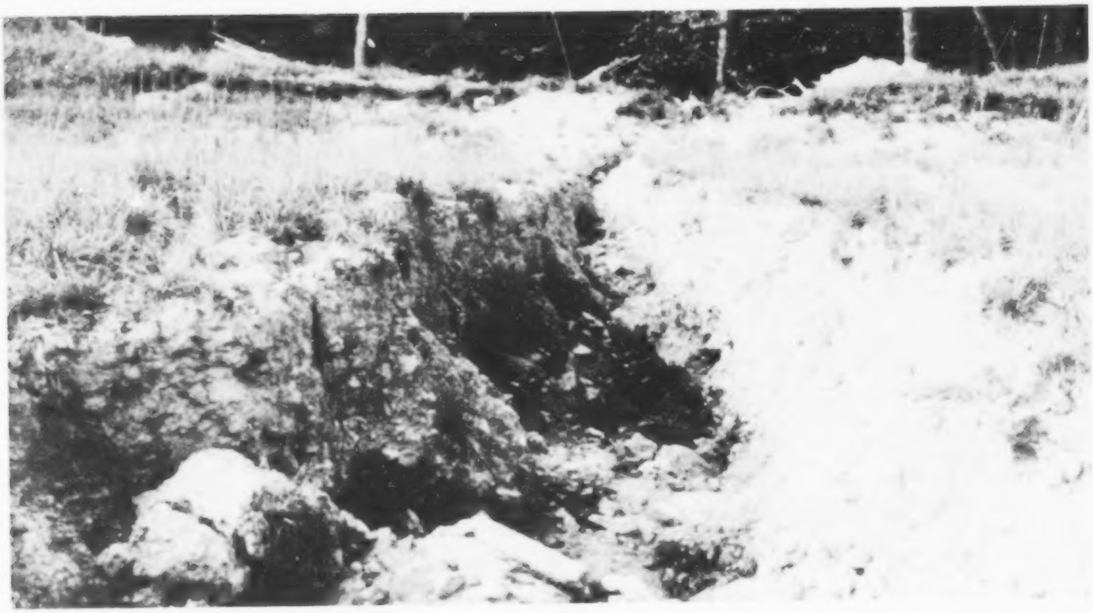


Figure 52. Erosion of hollow fill in Kentucky.

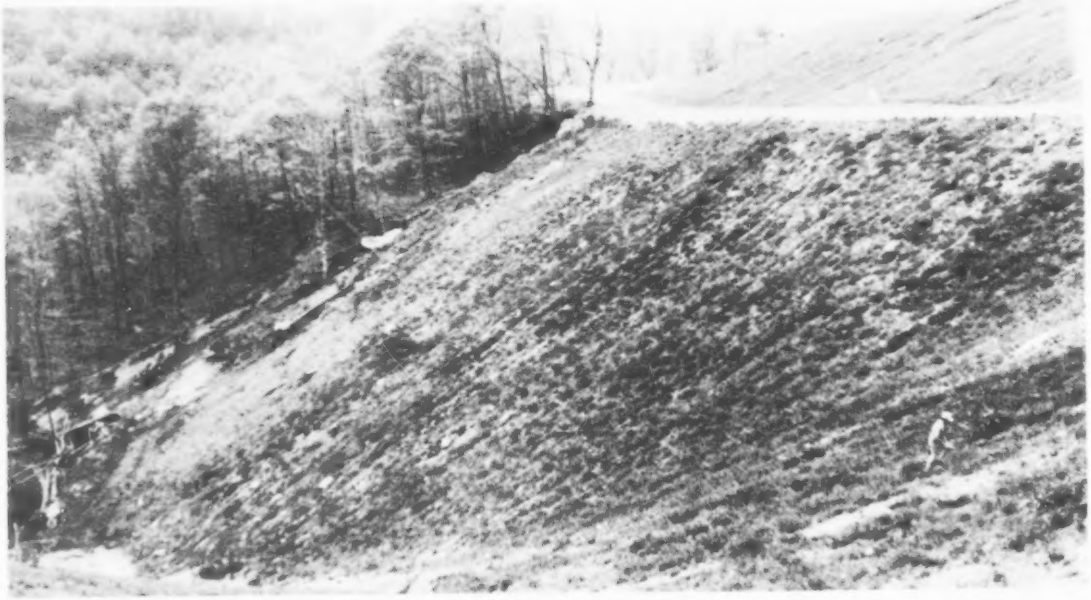


Figure 53. Long uninterrupted outslope in a Kentucky fill.

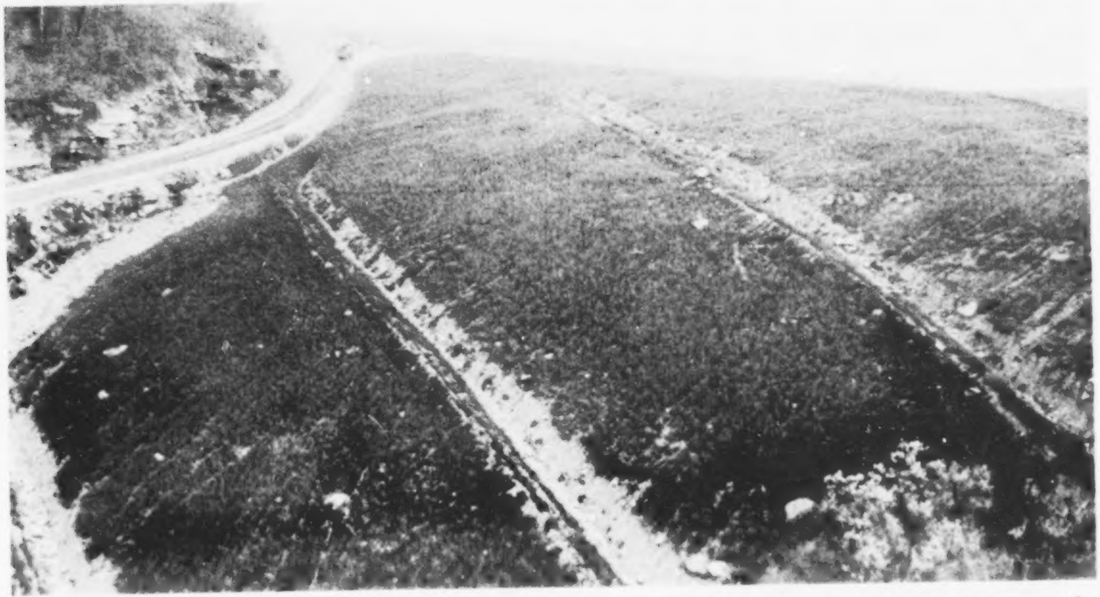


Figure 54. Kentucky fill outslope benched for erosion protection.

Final grading and application of the seed mixture is generally accomplished by dozers (Figure 55) and hydroseeders (Figure 56). The revegetated mine site and hollow fill will develop good ground cover after 1 or 2 growing seasons (Figures 57 and 58).

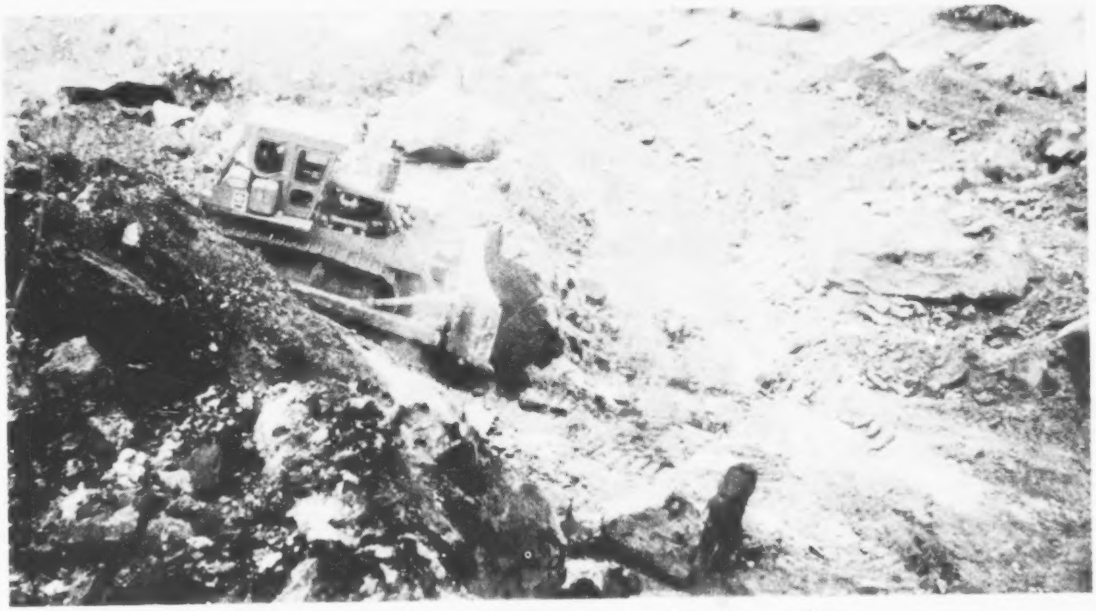


Figure 55. Regrading a hollow fill.

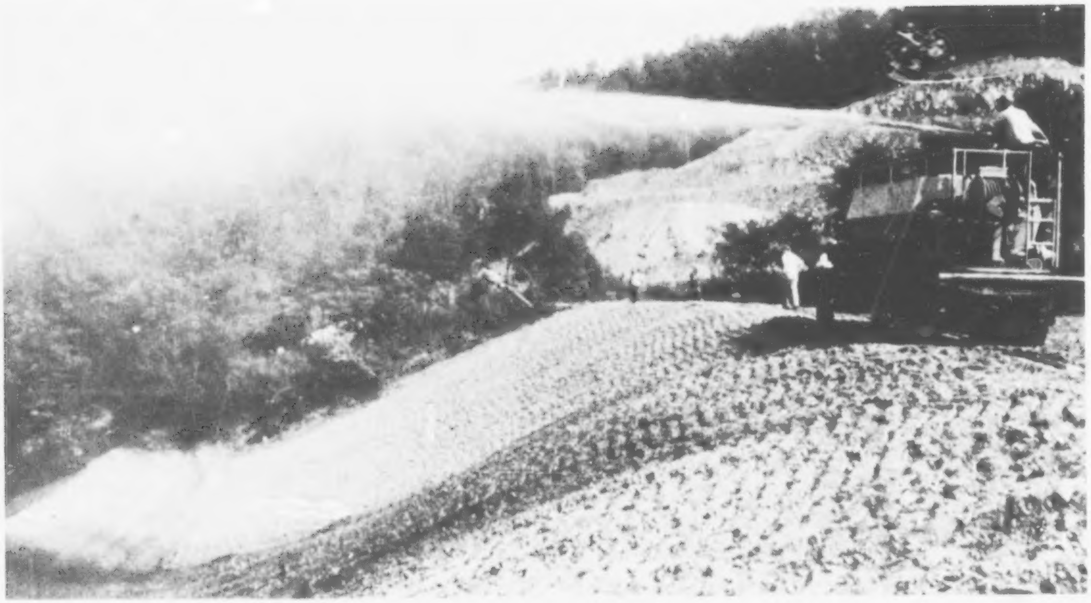


Figure 56. Revegetating by hydroseeder.

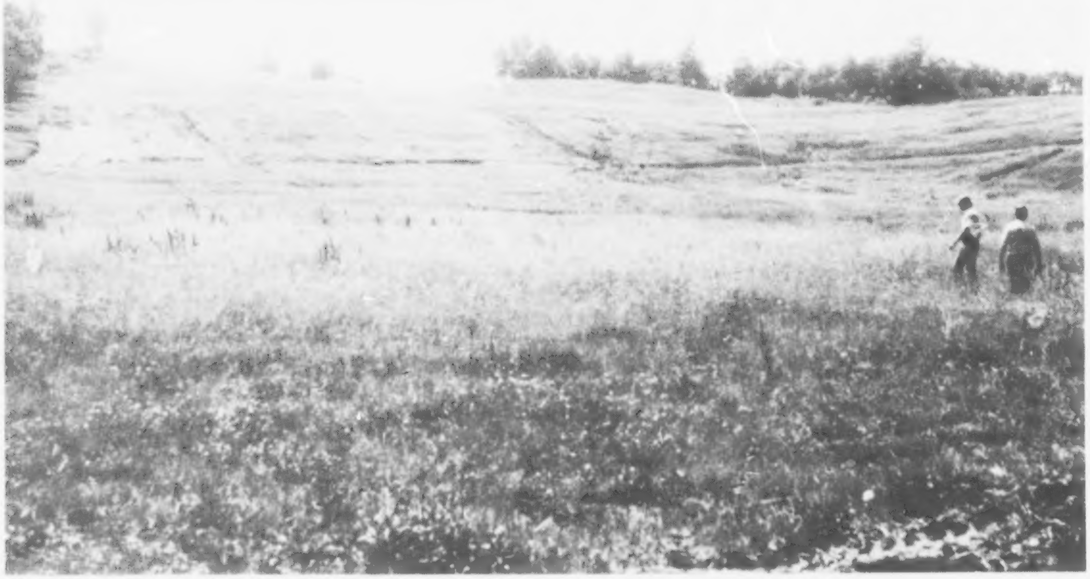


Figure 57. Revegetated mountaintop site.

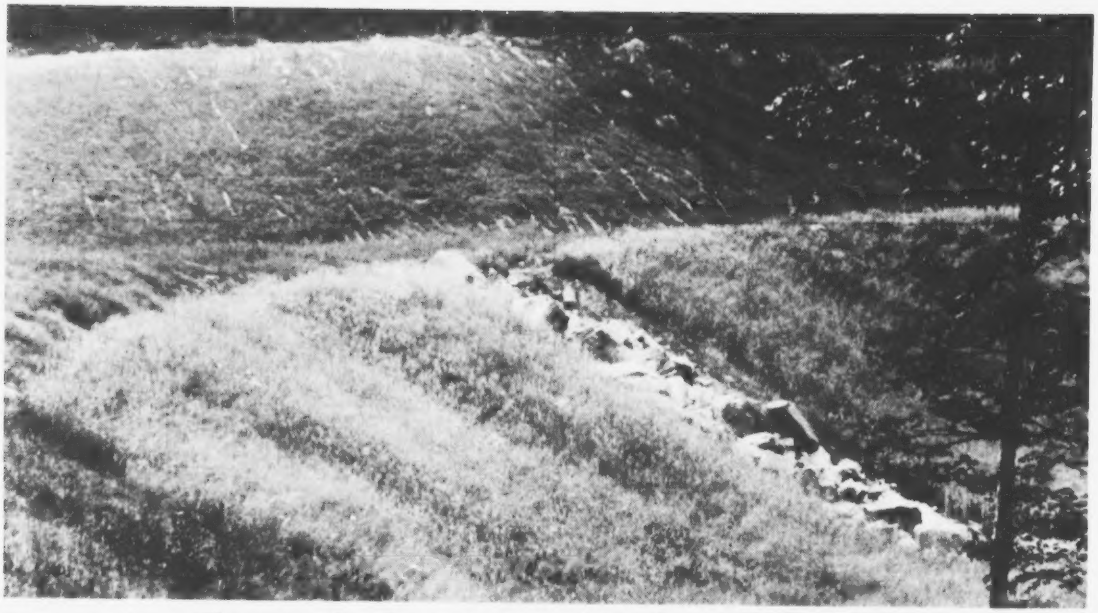


Figure 58. Revegetated head-of-hollow fill.

Considerable time and money is expended by mining companies in West Virginia and Kentucky to prevent erosion and water quality degradation. Evaluation of these problems is made by sampling the influent and effluent drainage of sediment control ponds. Continuous flow and water sampling equipment can be used for this monitoring task (Figures 59 and 60).

MINE SITE OBSERVATIONS

To obtain the broadest representation of mining practices, mine sites were chosen in various stages of development and with differing local mining conditions. As this phase of the study comes to an end, some mine sites are still actively operating with reclamation yet to be completed. Summary reviews of each mine site, including mining technique and hollow fills, are presented in Tables 43, 44, 45 and 46. These tables describe each site's assets and liabilities at the time of the last visit, but do not indicate final conditions.

A key question remains to be answered at each site: "Will the fill fail, and if so, to what extent?" A direct answer to this question is very difficult unless extreme conditions exist at a site. The character of the fill in regard to spoil placement, material type, erosion conditions, underdrain type, drain material, and function plays a predominant role in determining its final stability. Any one of these factors by itself usually will not

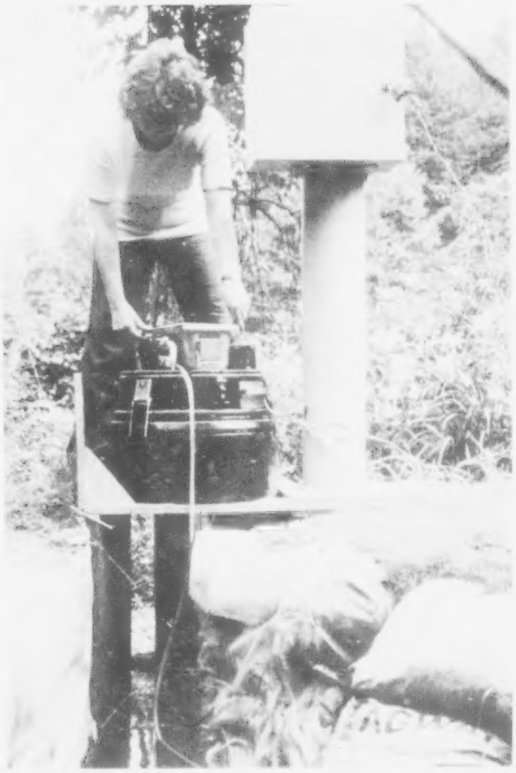


Figure 59. Water quality monitoring equipment.

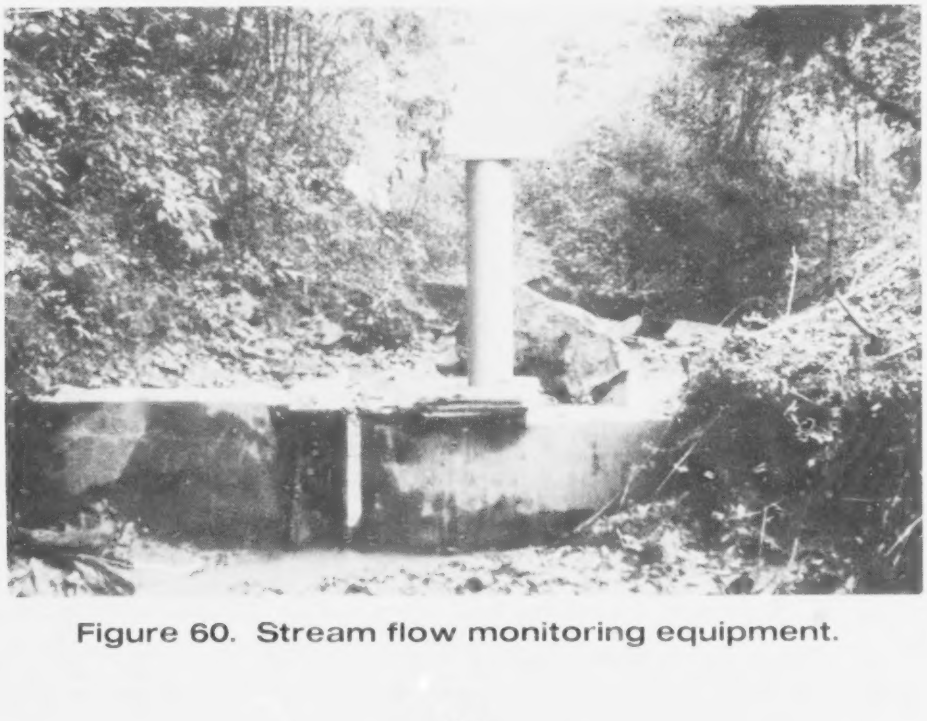


Figure 60. Stream flow monitoring equipment.

TABLE 43. WEST VIRGINIA MOUNTAINTOP SITE ASSESSMENT

MINE SITE	GEOLOGY		SOIL		EROSION		LAND USES	
	Asset	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*
BA	Multiple coal seam, high % sandstone	-	Good quality subsoil	No topsoil	Good diversion control	Steep terrain	Large flat land, excellent reclamation	Susceptible to high winds due to lack of windbreaks
HA	Multiple coal seam	High % shale	Can revegetate subsoil	No topsoil, some clay	Good diversion control	Steep terrain	Excellent reclamation, large tract of land	-
MA	Reasonable overburden	Relatively large % of shale	Good quality subsoil	No topsoil	Small area good diversion control	Steep terrain	Good reclamation	Small surface area location
OA	Reasonable overburden, high % sandstone	Strata acid producing	Good quality subsoil	No topsoil	Small area	Steep terrain	Excellent reclamation	Small surface area
PA	High % sandstone	-	Can revegetate subsoil	No topsoil	Small watershed, good runoff control	Steep terrain	Excellent reclamation	Small surface area

TABLE 44. KENTUCKY MOUNTAINTOP SITE ASSESSMENT

MINE SITE	GEOLOGY		SOIL		EROSION		LAND USES	
	Asset	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*
EA	High % sandstone	Strata acid producing	Subsoil can be revegetated	Little topsoil present	Used diversion ditches and mountaintop settling pond	Disturbed area large outslope steep	Good substrate excellent reclamation	Immediate area not higher inhabited
FA	Multiple coal seams	Large % shale and clays	Subsoil can be revegetated	Little to no topsoil present	Used diversion ditches and mountaintop lake	Disturbed area large, some localized erosion	Good reclamation large mountaintop lake	Location
GA	High % sandstone	Can be acid producing	Subsoil can be revegetated	No available topsoil	Surface area disturbed is small	Relatively steep slope not yet revegetated	Strip bench fairly wide particularly in hollows	Limited use, is contour stripped
IA	Multiple coal seams	Fair % of shale large overburden ratio	Subsoil can be revegetated	No topsoil	Good diversion practices and fair settling pond placement	Large area disturbed revegetation limited due to mining	Good substrate large flat land after mining hollow fill large and flat	Immediate uses limited by long term mining
KA	Multiple coal seams	One seam associated with acid producing strata	Subsoil can be revegetated	No topsoil available	Used diversion ditches, benches slope slightly toward highwall	Relatively steep terrain surrounding mine site	Wide flat area in the hollows	Limited uses contour stripped

TABLE 45. WEST VIRGINIA HEAD-OF-HOLLOW FILL SITE ASSESSMENT

MINE SITE	SITE PREPARATION		CORE		FILL FORM		EROSION	
	Asset	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*
BA	Site cleared	-	Durable sandstone	-	Toe on gentle slope	-	Core functioning reducing face erosion	Erosion along edges of fill
HA	Site cleared and windrowed	Slopes are steep	Sunken core for surface runoff	Very high % shale and weathering	Toe on gentle slope, small size	Surge pond drains into first bench	Little face erosion	-
MA	Site cleared	Fill toe on swamp land	Sunken core	Surge pond retaining water	Moderate slope	Water seepage top lift	Good diversion to core	Some moderate erosion on edges
OA	Site cleared and windrowed	Spring area in fill	Core primarily sandstone	Core is elevated	Good construction practices	Water seepage third lift	Good diversion to core	Moderate erosion along fill edge
PA	Site cleared	Very steep slopes	100% durable sandstone	Core is elevated	Small fill, small drainage area	-	Good runoff control	Slight face erosion due to elevated core

TABLE 45. (CONT'D) WEST VIRGINIA HEAD-OF-HOLLOW FILL SITE ASSESSMENT

MINE SITE	SEDIMENT POND		WATER QUALITY		REVEGETATION		WEATHER	
	Asset	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*
BA	Excellent Pond	-	No Acid	-	All completed lifts revegetated	-	Temperatures were near long term average	Precipitation well below normal until August
HA	Good excavated pond	-	No Acid, low TSS	-	Vegetation complete, good cover	-	Temperature near normal	Precipitation low in spring and summer, high during fall planting season
MA	Good excavated pond	-	No Acid, low TSS	-	Vegetation complete, good cover	-	Temperature near normal	Precipitation below normal until September except for heavy rain in June
OA	Good excavated pond	Pond too far from fill site	No Acid, low TSS	-	All completed lifts revegetated	-	Temperature near normal	Precipitation below normal until September except for June's heavy rain
PA	Excellent pond	-	No Acid, low TSS	-	100% cover	-	Temperature near long term average	Precipitation well below normal until August

TABLE 46. KENTUCKY HEAD-OF-HOLLOW FILL SITE ASSESSMENT

MINE SITE	SITE PREPARATION		UNDERDRAIN SYSTEM		FILL FORM		EROSION	
	Asset	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*
EA	Cleared and grubbed	Steep slopes	Good size segregation	Shale and clay present	Long slopes interrupted by benching	Very steep terrain	Excellent diversion control	-
FA	Cleared	Steep slopes	Fair size segregation	Shale and clay present	Not complete, no final grade	Having stability problems	Good diversion	No vegetative cover
GA	Cleared	Vegetation covered by fill	Fair size segregation	Shale, clay and organics present	Good grade, not too steep	Isolated areas of instability before grading	Diversion ditches and good grading	No vegetation on fill yet
IA	-	Vegetation covered by fill	Excellent size segregation	Shale, clay, coal prep. plant waste present	Toe will be on gentle slope	Poor compaction, tension cracks apparent	-	Very large area disturbed
KA	Cleared and material windrowed	Very steep slope	Fair segregation	-	A small fill	Steep outslopes	-	Bad erosion due to runoff passing over fill

TABLE 46. (CONT'D.) KENTUCKY HEAD-OF-HOLLOW FILL SITE ASSESSMENT

MINE SITE	SEDIMENT POND		WATER QUALITY		REVEGETATION		WEATHER	
	Asset	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*	*Asset*	*Liability*
EA	Good excavated pond	-	No acid discharge, low metals and TSS	-	Seeded with good mixture and heavy application rate	Did not seed until fall heavy rains	Temperature near normal	Precipitation below normal in Spring above normal during summer and fall
FA	Excellent pond	-	No acid discharge, low TSS	-	-	No cover, fill incomplete	Temperature near normal	Precipitation abnormal during all planting seasons
GA	-	Small rock dams only	No acid discharge, low iron	Moderate levels of TSS	-	No cover on fill	Temperature near normal	Precipitation extremely low during spring and early fall with excess rain in June and October
IA	Use series of rock dams	Rapidly silting in	No acid discharge	Relatively high levels of TSS	-	No cover on fill	Temperature near normal	Precipitation extremely low during spring then fluctuated between too much and not enough the remainder of year
KA	Good pond construction	-	No acid discharge	Moderate levels of TSS	Seeded before winter	Face erosion problems	Temperature near normal	Precipitation fluctuated continuously between extremes

result in a failure, but several in combination could lead to stability problems. A brief discussion of these factors will provide some insight into how fill stability can be assessed.

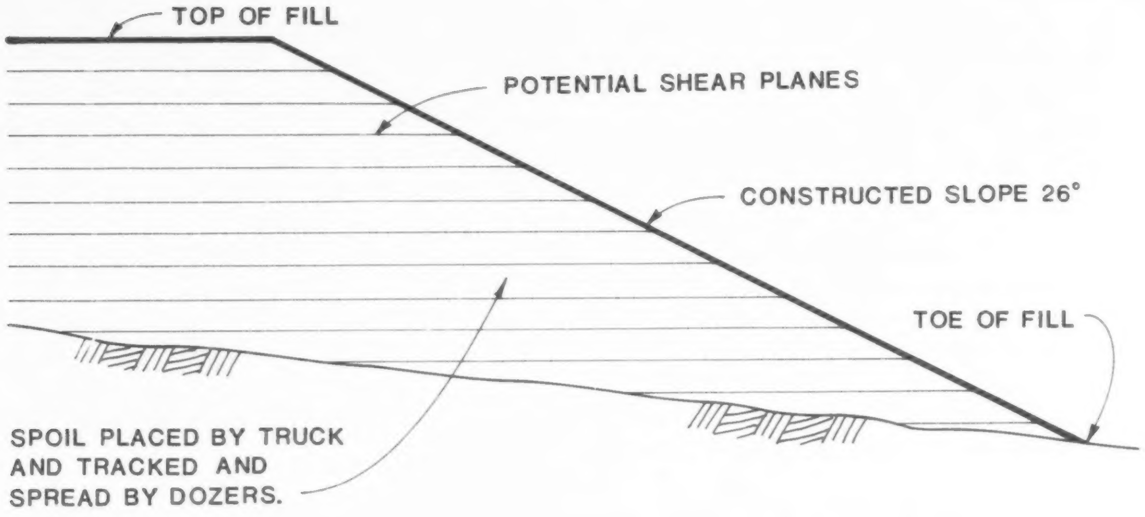
Method of spoil placement establishes particle alignment. Figure 61 illustrates the basic difference between placed spoil and end dumped materials. The cross-grain configuration of placed spoil tends to resist failure forces to a greater degree than the alignment parallel to the shear planes resulting from end dumping overburden.

The type of spoil used in the head-of-hollow fill is a function of the geology of the overburden. Because retention of water within the fill can significantly affect its stability, the best fill material is 100% sandstone and sandstone-derived soils, which retain less water than shales and clays.

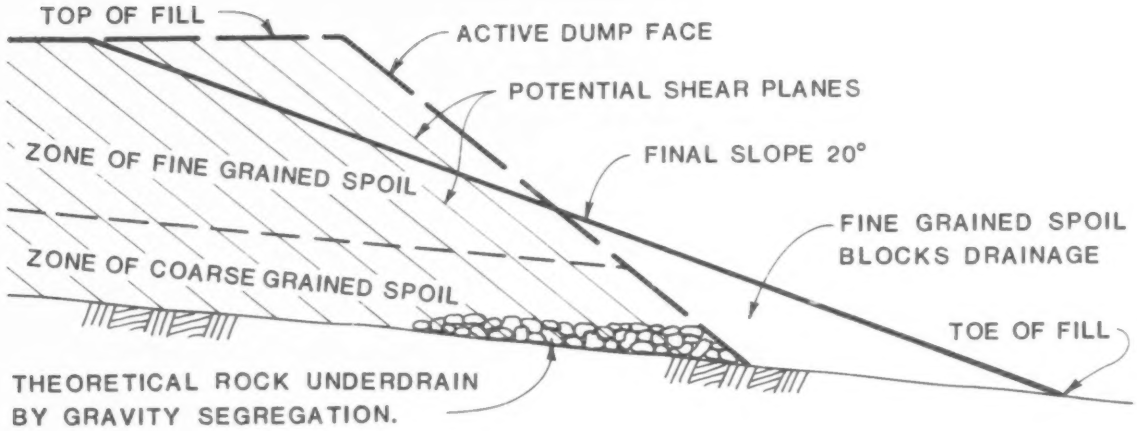
Limiting the amount of water entering the fill material and reducing its contact time help maintain stability. This is accomplished by diverting water away from the fill material through internal and external drainways. The rock core utilized in West Virginia serves both drainage duties provided the operators keep easily weatherable rock and fines out of the core and slightly depress it on finished slopes. Clogging of this drain reduces efficiency and increases retention time. Elevated cores can become clogged by silt at the fill surface-core interface, causing surface water to either pond or erode the face. On one particular instance, a heavy rainfall washed seed, mulch, and fertilizer from a recently seeded fill face against the protruding rock core. As the grasses grew, drainage from the bench was blocked, resulting in severe erosion along the fill surface-core interface.

Surge ponds placed at the head of the hollow fill regulate water flow to the drain from storm runoff, thus decreasing water velocity and erosion potential. Problems arise if this pond does not completely drain following each storm. Permanently retained water may create seep areas below the pond on the fill outslopes or may saturate the fill, changing the stability factors.

In Kentucky, on the other hand, the internal drain is formed during the end dumping process. Spoil is segregated by gravity as the material rolls down the hollow with large rocks reaching the bottom. Good operation of the drain depends on restricting the quantity of fines and weatherable material reaching the critical area. Kentucky's law requiring reduction of outslopes in hollow fills every 48 hours may effectively eliminate the natural formation of an underdrain system by clogging it with fines. Further blockage of water migration from the fill mass results when the final 20° grade (toeing out the fill) is established. Illustration 61 graphically portrays origin and final disposition of the fine grained spoil on completed Kentucky fills.


TOP OF FILL
POTENTIAL SHEAR PLANES
CONSTRUCTED SLOPE 26°
TOE OF FILL
SPOIL PLACED BY TRUCK AND TRACKED AND SPREAD BY DOZERS.

SPOIL PLACEMENT IN FILL (W. VA. STYLE)


TOP OF FILL
ACTIVE DUMP FACE
POTENTIAL SHEAR PLANES
FINAL SLOPE 20°
ZONE OF FINE GRAINED SPOIL
FINE GRAINED SPOIL BLOCKS DRAINAGE
ZONE OF COARSE GRAINED SPOIL
TOE OF FILL
THEORETICAL ROCK UNDERDRAIN BY GRAVITY SEGREGATION.

SPOIL FREE DUMPED IN FILL (KY. STYLE)

Figure 61. Typical internal structure of hollow fills.

Spoil compaction also plays a major role in ultimate fill stability. By compacting the material, greater cohesion is achieved and a lower failure potential exists. Through placing spoil in thin layers and compressing it by rubber-tired vehicles, good compaction is obtained in West Virginia. Unfortunately, a lower degree of compaction occurs in end dumping, because only the surface of the active dumping face is compressed.

Tension cracks and slip formations are outward signs of insufficient consolidation of the fill mass. Even if these failure areas are regraded and dressed-up, they generally will remain internally and could present problems at some future time.

Tables 47 through 56 summarize the conditions found at each site as related to the factors which influence fill stability.

Another area of critical impact is the effects on stream water quality resulting from disturbance of large tracts of land. Although water quality testing data have been presented with each mine site discussion (Section 6), for ease of comparison the data has been summarized by state and water source (Tables 57, 58, 59 and 60) and by key parameters (Tables 61 and 62). As can be readily seen, the state's mean values for West Virginia are consistently lower than Kentucky. This better effluent water quality may be attributed to differences in statewide mining practices such as:

- concurrent revegetation by lifts in West Virginia hollow fills
- filtering effects of the rock core
- better sediment pond control

WEST VIRGINIA HIGHWAY INDUSTRY

According to Mr. Robert K. Tinney, Administrative Engineer, West Virginia Construction Division, Department of Highways, the road contractor is wholly responsible for furnishing any waste sites necessary when there is excess material from a highway project. The contractor makes all the arrangements with the property owner and signs a contract with him. The site has to be approved by the Department of Highways using information from Form HL-445 (T) and field reviews of the site.

The manual entitled "Erosion and Sediment Control", West Virginia Department of Highways, April 1, 1972, defines the guidelines used for waste site control. The theory upon which this manual is based and by

TABLE 47. FILL CHARACTERISTICS FOR MINE SITE BA

TYPE CONSTRUCTION	Trucked to fill and spread
PERCENT COMPLETE	50%
GENERAL APPEARANCE	Good; some ponding of water on construction surface
CHARACTER OF FILL	Predominantly sandstone with moderate to high percentage of shale
TOP CONDITION	Fair to good; zoning of materials noted in the surface
FACE (SLOPE) CONDITION	Fair to good; erosion appears intermittent
TOE CONDITION	Fair to good
UNDERDRAINAGE BY	Through core of predominantly sandstone
CHARACTER OF U.D.	Some rocks appear to be oversized in places
FUNCTION	Function as underdrain appears to be fair to good
FOUNDATION DRAIN	Good to fair
SURFACE DRAINAGE TOP	Incomplete
FACE	Good with few erosion scars
SIDES	Erosion at interface appears to be a problem
LONG TERM OUTLOOK	Good; depends on existing water seepage and continued function of core drain

TABLE 48. FILL CHARACTERISTICS FOR MINE SITE HA

TYPE CONSTRUCTION	Trucked to site and spread
PERCENT COMPLETE	100%
GENERAL APPEARANCE	Good to very good; ridge-top location
CHARACTER OF FILL	Sandstone and shale; generally open-textured
TOP CONDITION	Good; appears to have good internal drainage
FACE (SLOPE) CONDITION	Good; some minor gullying
TOE CONDITION	Fair to good; narrow hollow at toe
UNDERDRAINAGE BY	Core of predominantly shale, some sandstone
CHARACTER OF U.D.	Shale fragments on surface appear to be weathering rapidly
FUNCTION	As underdrain fair to good at present time; surface function fair
FOUNDATION DRAIN	To core where possible; seepage minor
SURFACE DRAINAGE TOP	Good; some infiltration takes place; no ponding
FACE	Good; very minor gullying
SIDES	Good, minor gullying at fill-ground interface
LONG TERM OUTLOOK	Fair to good; overall stability should be satisfactory if water seepage does not materially increase; core may not effectively function over long term

TABLE 49. FILL CHARACTERISTICS FOR MINE SITE MA

TYPE CONSTRUCTION	Trucked to site and spread
PERCENT COMPLETE	100%
GENERAL APPEARANCE	Fair
CHARACTER OF FILL	Primarily shale; some sandstone and shale-derived soils
TOP CONDITION	Open graded but becoming more impervious as particles degrade; minor tension cracks on intermediate bench
FACE (SLOPE) CONDITION	Fair; seepage is apparent at some points on slope; will probably result in minor failures in future
TOE CONDITION	Fair to good
UNDERDRAINAGE BY	Through core; contains high percentage of shale
CHARACTER OF U.D.	Contains non-permeable zones
FUNCTION	Probably poor; surge pond at top is silted, preventing full drainage through core; inducing seepage in fill mass
FOUNDATION DRAIN	Inconclusive
SURFACE DRAINAGE TOP	To surge pond and infiltrate into fill mass
FACE	Fair with occasional seeps and gullying
SIDES	Good
LONG TERM OUTLOOK	Fair; predominance of shale-like materials may result in future development of excess seepage pressures

TABLE 50. FILL CHARACTERISTICS FOR MINE SITE OA

TYPE CONSTRUCTION	Trucked to fill and spread
PERCENT COMPLETE	Partial
GENERAL APPEARANCE	Good; slight seepage noted
CHARACTER OF FILL	Large percentage of shale-derived soils
TOP CONDITION	Fair to good; rutted mud or dusty in zones;
FACE (SLOPE) CONDITION	Good to very good; minor gullying on lower portions of slopes; no appreciable seepage
TOE CONDITION	Fair to good; located in sharp, V-shaped gully
UNDERDRAINAGE BY	Through core constructed of mostly sandstone; some shale; lateral drainage to core is apparently being attempted by intermittent rock layers
CHARACTER OF U.D.	Appears good and open-graded
FUNCTION	Function as surface drain appears to be intermittent, function as underdrain appears to be satisfactory
FOUNDATION DRAIN	Unknown; probably random seepage to core
SURFACE DRAINAGE TOP	Incomplete
FACE	Good; very minor gullying
SIDES	Good; some gullying at fill-ground interface
LONG TERM OUTLOOK	Good; providing core continues to function and seepage is controlled by it

TABLE 51. FILL CHARACTERISTICS FOR MINE SITE PA

TYPE CONSTRUCTION	Trucked to fill and spread; compacted by construction traffic
PERCENT COMPLETE	100%
GENERAL APPEARANCE	Very good to excellent
CHARACTER OF FILL	Primarily granular; little shale
TOP CONDITION	Gravelly, sandy appearance
FACE (SLOPE) CONDITION	Excellent; minor erosion at lower extremities of some lifts near core
TOE CONDITION	Excellent; located on wide, old coal bench
UNDERDRAINAGE BY	Through core constructed of sandstone rock
CHARACTER OF U.D.	Some sandstone fragments are extremely large
FUNCTION	As a surface drain, fair; function as underdrain appears unnecessary since entire fill is free-draining
FOUNDATION DRAIN	Through entire fill near toe region
SURFACE DRAINAGE TOP	Primarily internal
FACE	Primarily internal
SIDES	Primarily internal; no signs of major gullying
LONG TERM OUTLOOK	Excellent; long term consolidation should be minor

TABLE 52. FILL CHARACTERISTICS FOR MINE SITE EA

TYPE CONSTRUCTION	Free dump from top of fill (or bench?)
PERCENT COMPLETE	Completed, revegetated August 1976
GENERAL APPEARANCE	Good - minor erosion
CHARACTER OF FILL	Appears to be sandstone and shale; moderate to low percentage of shale-derived soils
TOP CONDITION	Undetermined
FACE (SLOPE) CONDITION	Subject to minor gullying; segregation incomplete; flattened slope appears satisfactory and open-textured
TOE CONDITION	Apparently set on felled vegetation
UNDERDRAINAGE BY	Natural segregation
CHARACTER OF U.D.	Sandstone and shale fragments by segregation blanket
FUNCTION	Appears fair to good
FOUNDATION DRAIN	Through underdrain blanket
SURFACE DRAINAGE TOP	Flattened slopes appear satisfactory
FACE	Some minor gullying on working face
SIDES	Good
LONG TERM OUTLOOK	Fair to good for completed fill

TABLE 53. FILL CHARACTERISTICS FOR MINE SITE FA

TYPE CONSTRUCTION	Free dump from top of fill
PERCENT COMPLETE	80%: final slope not yet established
GENERAL APPEARANCE	Poor to fair; talus-like slopes
CHARACTER OF FILL	Appears to be primarily shale with moderate to high percentage of shale-derived soils, some sandstone
TOP CONDITION	Appearance of tension cracks and slip failures
FACE (SLOPE) CONDITION	Talus slope; segregation is incomplete; some severe gullying; some minor slides and mud-flows
TOE CONDITION	Appears to be on residual clay soils
UNDERDRAINAGE BY	Segregated blanket (theoretical)
CHARACTER OF U.D.	Some sandstone, but primarily shale and clay
FUNCTION	Does not appear to be functioning very well, seepage is causing slide failures and mud-flows
FOUNDATION DRAIN	Probably poor
SURFACE DRAINAGE TOP	Undetermined
FACE	Some gullying
SIDES	Fair
LONG TERM OUTLOOK	Poor to fair; without additional drainage, failures will continue; probably excessive long term consolidation of clay materials throughout fill

TABLE 54. FILL CHARACTERISTICS FOR MINE SITE GA

TYPE CONSTRUCTION	Free dump
PERCENT COMPLETE	95%: partly revegetated
GENERAL APPEARANCE	Good: final grade complete
CHARACTER OF FILL	Appears to be predominantly shale and shale-derived soils with a large percentage of degradable sandstone
TOP CONDITION	Good; dusty in traffic area
FACE (SLOPE) CONDITION	Good
TOE CONDITION	Fair; large percentage of fine-grained soils have migrated to toe area; clearing is incomplete in toe area
UNDERDRAINAGE BY	Theoretical segregation of particles; inconclusive
CHARACTER OF U.D.	Shale, silt-clay soils and sandstone
FUNCTION	Inconclusive
FOUNDATION DRAIN	Probably fair; foundation soils left in-place will probably consolidate and become less pervious
SURFACE DRAINAGE TOP	Fair to good
FACE	Similar to talus-slope before regrading
SIDES	Good
LONG TERM OUTLOOK	Fair to good

TABLE 55. FILL CHARACTERISTICS FOR MINE SITE IA

TYPE CONSTRUCTION	Free dump from top of fill
PERCENT COMPLETE	50%
GENERAL APPEARANCE	Poor to fair
CHARACTER OF FILL	Shale and sandstone, some refuse and shale-derived soils
TOP CONDITION	Fair to good; traffic area for hauling; large tension cracks at all active dump points
FACE (SLORE) CONDITION	Talus slope; numerous slides apparent on active dump zone
TOE CONDITION	Broad valley
UNDERDRAINAGE BY	Segregated blanket underdrain
CHARACTER OF U.D.	Primarily sandstone and shale through segregation
FUNCTION	Undetermined
FOUNDATION DRAIN	Through blanket
SURFACE DRAINAGE TOP	Fair to good by grading; some ponding and dusting
FACE	Absorptive talus; minor gullying
SIDES	Same as face
LONG TERM OUTLOOK	Fair to good; fill will be partially contained on sides by existing highwalls; thereby buttressing against lateral failures; consolidation of fill is expected to be long term problem and may be excessive

TABLE 56. FILL CHARACTERISTICS FOR MINE SITE KA

TYPE CONSTRUCTION	Free dump from bench
PERCENT COMPLETE	Completed, revegetated
GENERAL APPEARANCE	Fair
CHARACTER OF FILL	Primarily shale; some sandstone; large percentage of shale-derived soils
TOP CONDITION	Fair; primarily fine-grained soils exposed on traffic area; tendency to mud or dust
FACE (SLOPE) CONDITION	Fair; some major gullying where drain water runs across fill
TOE CONDITION	Fair; felled trees are windrowed
UNDERDRAINAGE BY	Segregation of particles in dumping procedure; slides occurring just above this type of "drain" tend to carry fines into the "drain" area
CHARACTER OF U.D.	Unknown; estimated to be primarily shale
FUNCTION	Unknown; rate of migration of fines into this drain is undetermined at this time
FOUNDATION DRAIN	By segregation of particles forming theoretical drain blanket; function unknown
SURFACE DRAINAGE TOP	Good
FACE	Fair; major gullying present
SIDES	Fair to good
LONG TERM OUTLOOK	Fair; the existing slopes are extremely steep

TABLE 57. WATER QUALITY DATA GENERAL ASSESSMENT SITES

WEST VIRGINIA INFLUENT

YEAR	MONTH	MINE SITE	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
1976	*SEPTEMBER*	BA	7.9	180	0	.63	<5	330	627	8	100	124	1.5	<.1	<.01	.29	<.01	<.03	.14	865
		HA	1.7	0	2000	.54	90	140	5069	44	64	21	.88	.3	<.01	.04	<.01	<.03	.03	10400
		MA	6.9	40	0	.14	5	60	173	10	31	8.5	.01	<.1	<.01	.31	<.01	<.03	<.01	250
	NOVEMBER	BA	7.2	126	0	.72	<5	250	620	12	110	66	1.1	.1	<.01	.24	<.01	<.03	<.01	870
		HA	7.7	132	0	-	<5	540	1024	<1	-	-	-	-	-	-	-	-	.01	1305
		MA	6.7	26	0	.57	<5	20	71	3	59	6.2	.02	.3	<.01	.34	<.01	<.03	<.01	120
		OA	6.9	32	0	-	35	125	317	35	-	-	-	-	-	-	-	-	.22	360
	DECEMBER	BA	7.3	100	0	1.7	48	250	770	140	110	61	1.0	.7	<.01	.37	<.01	<.03	.01	750
		HA	6.6	44	0	.36	2.0	700	1270	6	200	140	1.1	.1	<.01	.44	<.01	<.03	.03	1360
		MA	7.0	34	0	.71	25	80	190	20	95	10	.03	.4	<.01	.52	<.01	<.03	.05	240
		OA	7.2	40	0	.54	25	115	380	120	25	29	5.2	.2	<.01	.14	<.01	<.03	.21	350

Note: All units mg/l except where noted.

TABLE 58. WATER QUALITY DATA GENERAL ASSESSMENT SITES

WEST VIRGINIA EFFLUENT

YEAR	MONTH	MINE SITE	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (µmhos/cm)
1976	FEBRUARY	HA	6.7	24	0	18	<5	140	350	16	36	21	.10	<.1	<.01	.02	<.01	.03	<.01	460
	APRIL	HA	6.5	28	2	.11	5	175	390	4	70	60	.15	<.1	<.01	.04	<.01	<.03	<.01	515
		MA	7.1	64	0	.40	30	83	290	30	66	20	.16	.10	<.01	.02	<.01	<.03	.02	345
		OA	6.3	16	2	.70	100	50	180	50	19	13	.04	.60	<.01	.02	<.01	<.03	.21	170
	JUNE	BA	6.7	58	0	.20	10	270	550	14	60	39	-	.10	<.01	.17	<.01	-	-	640
		HA	6.8	70	0	.51	5	700	1170	3	92	49	-	.10	<.01	.07	<.01	-	-	1240
		OA	6.5	42	0	.09	10	60	160	21	10	17	-	<.10	<.01	<.01	<.01	-	-	230
	AUGUST	BA	6.7	66	0	.43	<5	250	510	26	76	63	.41	.2	<.01	.40	<.01	<.03	.13	955
		HA	6.6	66	0	.57	45	130	362	32	31	24	.53	.3	<.01	.14	<.01	<.03	1.1	390
		MA	7.9	162	0	<.01	<5	90	292	22	60	27	.01	<.1	<.01	.37	<.01	<.03	.02	455
		PA	6.1	16	4	.1	40	40	114	28	8.8	20	.5	<.1	<.01	.08	<.01	<.03	.03	225
	SEPTEMBER	BA	7.3	60	0	.34	<5	180	401	3	59	40	.53	<.1	<.01	.05	<.01	<.03	<.01	500
		HA	7.2	44	0	.30	10	175	349	24	79	37	.09	.2	<.01	<.01	<.01	<.03	.07	430
		MA	7.5	138	0	.78	75	125	372	34	85	25	.70	.1	<.01	.18	<.01	<.03	.31	460
		OA	6.7	24	0	-	5	60	151	8	-	-	-	-	-	-	-	-	.09	250
		PA	6.4	14	0	-	5	30	170	<1	-	-	-	-	-	-	-	-	.04	235
	DECEMBER	BA	7.4	44	0	1.0	6.5	290	420	13	73	37	.47	.2	<.01	.20	<.01	<.03	.01	410
		HA	7.2	46	0	.64	17	175	350	11	60	34	.33	.2	<.01	.20	<.01	<.03	.08	450
		MA	7.3	66	0	.58	48	90	260	35	70	17	.30	.3	<.01	.54	<.01	<.03	.13	300
		PA	6.5	14	0	.20	11	45	200	12	37	21	.41	.1	<.01	.39	<.01	<.03	.12	240

Note: All units mg/l except where noted.

TABLE 59. WATER QUALITY DATA GENERAL ASSESSMENT SITES

KENTUCKY INFLUENT

YEAR	MONTH	MINE SITE	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
1976	APRIL	FA	7.8	228	0	.07	5	2200	3925	11	372	370	1.4	<.1	<.01	.04	.01	.17	.04	3530
		IA	6.5	20	2	2.7	400	93	1320	345	112	70	2.2	2.1	.02	.14	<.01	.09	.03	1715
	JUNE	FA								NO ACCESS										
		IA	6.4	38	0	1.4	110	340	760	85	60	34	2.4	.5	<.01	.16	<.01	.04	<.01	830
	AUGUST	FA	7.4	280	8	.09	<5	2400	4470	16	328	470	.82	<.1	<.01	.06	<.01	.09	.02	3550
		IA	6.9	80	0	.44	10	250	738	22	57	45	3.2	.3	<.01	.04	<.01	.07	<.01	925
	OCTOBER	FA	7.6	320	0	.17	15	2325	4100	40	436	67	3.4	<.1	<.01	.06	<.01	.11	.17	3600
		IA	7.2	54	0	1.5	75	190	570	100	56	52	1.7	.4	<.01	.27	<.01	.03	1.2	650
	NOVEMBER	FA	7.4	325	0	.4	<5	2240	3862	2	500	450	2.9	.1	<.01	.21	<.01	.12	<.01	3400
		IA	7.1	112	0	.67	370	220	793	291	107	39	2.2	.3	<.01	.24	<.01	.05	.77	710

Note: All units mg/l except where noted.

TABLE 60. WATER QUALITY DATA GENERAL ASSESSMENT SITES

KENTUCKY EFFLUENT

YEAR	MONTH	MINE SITE	pH	ALKALINITY	ACIDITY (HOT)	TOTAL IRON	TURBIDITY	SULFATE	TOTAL SOLIDS	TOTAL SUSPENDED SOLIDS	CALCIUM	MAGNESIUM	MANGANESE	ALUMINUM	COPPER	ZINC	CADMIUM	NICKEL	DISSOLVED IRON	SPECIFIC CONDUCTIVITY (μmhos/cm)
1976	*FEBRUARY*	FA	5.9	12	20	<.01	<5	260	450	18	30	22	7.9	<.1	<.01	.36	<.01	.30	<.01	690
	APRIL	FA	7.8	198	0	1.0	15	1875	3675	11	296	365	1.4	<.1	<.01	.02	.01	.10	.04	3700
		GA	8.1	328	0	1.0	25	20	680	26	75	45	6.7	.1	.05	.08	<.01	<.03	.02	640
		IA	6.5	24	2	2.0	250	85	1260	275	87	103	2.5	1.0	<.01	.12	<.01	.07	.02	1650
		KA	7.4	52	0	.48	70	70	240	65	30	20	.02	1.2	<.01	.01	<.01	<.03	.15	275
	JUNE	FA								NO ACCESS										
		GA	6.9	92	0	2.6	220	260	640	150	59	37	2.7	.7	<.01	.09	<.01	<.03	<.01	630
		IA	6.9	34	0	1.8	80	265	590	50	80	39	2.9	.8	<.01	.20	<.01	.08	<.01	700
		KA	6.6	70	0	3.0	150	300	625	150	59	39	2.5	1.5	<.01	.10	<.01	<.03	<.01	650
	AUGUST	FA	7.5	236	10	.32	10	1950	3700	19	280	350	1.4	<.1	<.01	.08	<.01	.05	.01	3075
		GA	7.3	102	0	<.01	5	180	424	9	45	35	.03	<.1	<.01	.12	<.01	<.03	<.01	525
		IA	7.2	74	0	.45	10	250	676	6	55	43	3.0	<.1	<.01	.12	<.01	.06	<.01	870
		KA	7.5	284	2	1.7	5	70	502	8	58	51	18	<.1	<.01	.01	<.01	<.03	<.01	720
	OCTOBER	EA	7.4	62	0	–	90	60	230	60	25	–	–	–	–	–	–	–	.43	265
		FA	7.9	286	0	.71	5	1990	3570	6	424	6.2	3.8	.3	<.01	.71	<.01	.09	.70	3060
		GA	7.9	150	0	.59	25	310	640	15	85	89	2.4	<.1	<.01	.16	<.01	<.03	.59	820
		IA	7.2	48	0	.79	85	160	480	60	50	44	1.5	.2	<.01	.14	<.01	<.03	.74	610
		KA	7.5	94	0	1.2	30	240	490	20	63	61	2.4	.1	<.01	.16	<.01	<.03	1.2	610
	NOVEMBER	EA	7.2	74	0	.95	5	90	204	1	39	17	.88	<.1	<.01	.09	<.01	<.03	.36	295
		FA	7.6	246	4	.83	<5	1700	2808	3	350	290	5.5	<.1	<.01	.06	<.01	.04	<.01	2670
		GA	6.2	9.0	4	.1	<5	8.3	54	2	17	2.5	<.01	<.1	<.01	.08	<.01	<.03	.08	50
		IA	7.4	80	0	3.6	15	180	466	18	107	43	2.8	1.9	<.01	.24	<.01	.06	.05	600
		KA	7.5	228	6	4.4	<5	280	688	4	120	96	71	<.1	<.01	.02	<.01	<.03	<.01	920

Note: All units mg/l except where noted.

TABLE 61. SUMMARY OF EFFLUENT KEY MINE DRAINAGE PARAMETERS

MINE SITE		pH			TOTAL IRON			SULFATE			TURBIDITY			TOTAL SOLIDS			SUSPENDED SOLIDS		
		MAX.	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.	MIN.	MEAN
WEST VIRGINIA	BA	7.3	6.7	-	.43	.20		270	180		10	<5		550	401		26	3	
	HA	7.2	6.5	-	.57	.11	.39	700	130	249	45	<5	14	1170	349	495	32	3	15
	MA	7.9	7.1	-	.78	<.01	.44	125	83	97	75	<5	40	372	290	304	34	22	30
	OA	6.7	6.3	-	.70	.09	.40	60	50	57	100	5	38	180	151	164	50	8	26
	PA	6.4	6.1	-	.2	.1	.15	45	30	38	40	5	19	200	114	161	28	<1	14
	STATE	-	-	-	.78	<.01	.40	700	30	158	100	<5	22	1170	114	352	50	<1	19
KENTUCKY	EA	7.4	7.2	-	.95	-	.95	90	60	75	90	5	48	230	204	217	60	1	30
	FA	7.9	5.9	-	1.0	<.01	.56	1990	260	1555	15	<5	8	3700	450	2841	19	3	11
	GA	8.1	6.2	-	2.6	<.01	.86	310	8.3	156	220	<5	56	680	54	488	150	2	40
	IA	7.4	6.5	-	3.6	.45	1.73	265	85	188	250	10	88	1260	466	694	275	6	82
	KA	7.5	6.6	-	4.4	.48	2.2	300	70	192	150	<5	52	688	240	509	150	4	49
	STATE	-	-	-	4.4	<.01	1.31	1990	8.3	482	250	<5	51	3700	54	105	275	1	44
OVERALL		-	-	-	4.4	<.01	.89	1990	8.3	318	250	<5	37	3700	54	223	275	1	32

Note: All units mg/l except where noted.

TABLE 62. SUMMARY OF EFFLUENT METAL ANALYSES OF MINE DRAINAGE

MINE SITE		ALUMINUM			CALCIUM			DISSOLVED IRON			MAGNESIUM			MANGANESE			ZINC		
		MAX.	*MIN.*	*MEAN*	*MAX.*	*MIN.*	*MEAN*	*MAX.*	*MIN.*	*MEAN*	*MAX.*	*MIN.*	*MEAN*	*MAX.*	*MIN.*	*MEAN*	*MAX.*	*MIN.*	*MEAN*
WEST VIRGINIA	BA	.10	<.1	.2	76	59	67	.13	<.01	.05	63	39	45	.53	.41	.47	.40	.05	.21
	HA	.10	<.1	.2	92	31	61	1.1	<.01	.25	60	21	38	.53	.09	.24	.14	<.01	.08
	MA	.10	<.01	.2	60	85	70	.31	.02	.12	27	20	22	.70	.01	.29	.37	.02	.28
	OA	.60	<.10	.4	19	10	14	.21	.09	.15	17	13	15	.04	–	.04	.02	<.01	.02
	PA	.1	<.1	.1	37	8.8	23	.12	.03	.06	21	20	20	.5	.41	.45	.39	.08	.24
	STATE	.6	<.01	.2	92	8.8	55	1.1	<.01	.15	63	13	32	.70	.01	.31	.40	<.01	.12
KENTUCKY	EA	<.1	–	.1	39	25	32	.43	.36	.40	17	–	17	.88	–	.88	.09	–	.09
	FA	.3	<.1	.2	424	30	276	.70	<.01	.15	365	6.2	207	7.9	1.4	4	.71	.02	.25
	GA	.7	<.1	.02	85	17	56	.59	<.01	.14	89	2.5	42	6.7	<.01	2.4	.16	.08	.11
	IA	7.4	6.5	.8	107	50	86	.74	<.01	.17	103	39	54	3.0	1.5	2.5	.24	.12	.16
	KA	7.5	6.6	.6	120	30	66	1.2	<.01	.28	96	20	53	71	.02	18.8	.16	.01	.06
	STATE	7.5	<.1	.4	424	17	113	1.2	<.01	.20	365	2.5	86	71	.01	6.63	.71	.01	.14
OVERALL		7.5	<.01	.3	424	8.8	87	1.2	<.01	.18	365	2.5	61	71	.01	3.90	.71	<.01	.13

Note: All units mg/l except where noted.

which the West Virginia Department of Highways functions is divided into four segments:

- compact the face of the fill at the end of each work day and if the fill is to be temporarily abandoned
- control erosion using brush, rocks, or sediment ponds
- cover exposed soils with temporary matting, mulches or vegetation and replace or supplement with permanent vegetation at completion of construction
- reduce area and/or duration of exposure to the elements.

Dr. Blazer, a professor at Virginia Polytechnic Institute associated with the National Highway Research Board, has done extensive ground cover studies and research on slope smoothness in relation to speed and success of revegetation. It appears now that, unless the finished face of the outslope has to be finely graded for appearances (highly populated areas only), a rougher surface is more conducive to fast and effective revegetation. The West Virginia Highway Department is using this idea in test plots along I-79 near Charleston. The field team will tour the test plots on the next trip to West Virginia and information on the plots will be made available to them. This information may help in making recommendations for the final report on the Mountaintop Removal and Head-of-Hollow Fill project.

If the outslope of the fill is near a stream, a number of precautions are taken by the Highway Department:

1. the outer edge is lined with a 3 meter (10 foot) wide area of rock
2. small settling ponds are used
3. slope of the face is not permitted to be over 2:1
4. cover of some kind is provided as soon as possible
5. the outslope is compacted daily

A ninety-five percent (95%) compaction is required on the top 5 meters (16 feet) of the fill utilizing the same equipment as that employed on the associated highway embankment. The "roller pass method" monitors compaction after each pass of the equipment over the fill to determine the optimum degree of compaction for the fill material. Compaction is checked one of two ways by the Highway Department:

1. densometer - similar to "sand cone" method
2. nuclear probe - recently popular

Highway embankments are compacted in 0.6 meter (2 foot) maximum lifts for rocky material and 20 cm (8 inch) maximum lifts for fine material.

The Division of Design of the West Virginia Department of Highways gets involved with waste site construction only if a major problem develops. Otherwise they are concerned solely with the highway site itself.

Specific information has been obtained from the Department of Highways, West Virginia, on certain waste disposal areas along I-79 between Frametown and Charleston, West Virginia, and will be discussed in the final report. The waste disposal areas and descriptions of the sites are presented in Table 63.

LAND USE POTENTIAL

Mountaintop removal mining techniques, aside from supplying an essential resource, may also provide depressed regions of Appalachia with a badly needed new resource: developable land.

Land usage, limited by the jagged topography of the region, has been restricted to available bottom lands in the narrow stream valleys, where main agricultural, residential, and industrial centers are located. This shortage of level terrain has been a principal limiting factor in the economic development of the socio-geographic region known as Appalachia. At present, the surface mining techniques (Mountaintop Removal, and associated Head-of-Hollow Fill) now in use in southern West Virginia and eastern Kentucky offer the only economically feasible method of obtaining such land. Surface mining operations will now become dual commodity industries, providing both level land and coal, in a region and time where both are sorely needed.

Preplanning land use before mining operations are begun is a highly desirable course of action, thus facilitating the quality of the final product after reclamation. With proper regrading and soil preparation, many areas previously strip mined can be converted into highly productive valuable land, although benefit-cost ratios may sometimes be lower if land use is not considered prominently in the mining scheme planning.

Concern for aesthetics of a site has increased greatly in reclamation planning and implementation. However, it is an extremely subjective factor which can be related to reclamation in many ways, as the authors of a report entitled "The Aesthetics of Surface-Mine Reclamation: an On-Site Survey in Appalachia" point out.(7) The most creative and useful way of conceptualizing a reclaimed site is as a recomposed landscape - a design - in which the trees, grass, shrubs, rocks, access roads, paths, impoundments, diversion ditches, drainways and embankments are part of a unified and integrated scheme. All elements of the landscape should harmonize with the surrounding environment while reflecting the final land use

TABLE 63. SUMMARY OF W. VA. HIGHWAY WASTE DISPOSAL SITES

Site No.	Location (Road Marker)	Fill Size			Drainage Channel		Vegetation		Erosion	
		Length	Width	Height	Location	Description	Type	% Cover	Location	Magnitude
1	2723 + 00	182.9 (600)	91.4 (300)	12.2 (40)	Center	sandstone riprap "V" shaped	rye clover grasses	50 front 75 back	Face Top	Minor Minor
2	2565 + 00	152.4 (500)	91.4 (300)	7.6 (25)	Left Edge	riprap drain	clover grasses	85	Face	Minor
3	2526 + 00	274.3 (900)	61.0 (200)	6.1 (20)	Left Edge	riprap drain	clover grasses	85	Face	Minor
4	2173 + 00	304.8 (1,000)	182.9 (600)	27.4 (90)	Left Edge	riprap total length	rye clover grasses	75	Top	Minor
					Center	riprap, bottom half face			Face	Minor
5	2122 + 00	91.4 (300)	45.5 (150)	3.0 (10)	not apparent		clover grasses	75	Face	Minor
6	1318 + 00	365.8 (1,200)	167.6 (550)	30.5 (100)	Right Edge	riprap	clover grasses	70	Face	Major, Left of Center
		91.4 (300)	45.5 (150)	7.6 (25)	Center	riprap	grasses	75	Top	Minor
7	1240 + 00	121.9 (400)	61.0 (200)	4.6 (15)	Right Edge	riprap	clover grasses vetch	75	Face	Minor
8	1226 + 00	213.4 (700)	61.0 (200)	6.1 (20)	Center	riprap	clover grasses vetch	75	Face	Minor

Fill Size Measurements are in meters and (feet) of the site. It must be emphasized that land use planning should be considered on a regional basis and not limited to a short term isolated site approach. These considerations are especially important in mountaintop removal mining, because of the large tracts of land involved and the potential effects on a wide area.

The long term impact of this type of mining on the beautiful mountainous regions of southern West Virginia and eastern Kentucky should be of great concern to everyone. Ignoring aesthetics could result in steep rugged landforms sheared to flatness, with none left standing to relieve visual monotony. With a rational approach to utilization of our natural resources we can strike a balance between aesthetics and economics, providing developable land while retaining the beauty of the mountains.

Land that has been transformed into flat areas as a result of mountaintop removal mining has been and/or will be used for a variety of purposes. Table 64 provides examples of alternative land uses ranging from single industry resort developments (tourism) to complete pre-planned communities with hospitals, hotels, airports, shopping centers, schools, and residential areas. In instances where properly reclaimed land has been returned to agricultural uses, yields have been reported to be as good, if not better, than that obtained before mining.(6)

Often, when concepts appear to offer many benefits, one becomes naturally suspicious of hidden liabilities and costs; however, mountaintop mining and reclamation methods, when planned and implemented, will result in creation of our primary resource - productive land.

TABLE 64. ALTERNATIVE USES OF SOME RECLAIMED SURFACE MINES*

I. COMMERCIAL	LOCATION
1. Airport	Williamson
2. Airport	Logan
3. Sanitary Landfill	Logan
4. Airport	Hazard
5. Deep Mining Complex	Bull Creek
6. Deep Mining Complex	Upshur County
7. Coal Preparation Plant	Kayford
8. Sawmill	Walkersville
9. Sawmill	Preston County
10. Cannelton Farms	Ward
11. Apple Orchard	Buffalo
12. Apple Orchard	Bradshaw
II. HOUSING	
1. Planned Community (10,000)	Ward
2. Residential Developments	Beckley
3. Residential Developments (With private airfield)	Corrine
4. Residential Developments	Peach Creek
5. Residential Developments (Rush Creek)	Kanawha County
6. Mobile Home Park	Buckhannon
7. Mobile Home Park	Osage
III. PUBLIC FACILITIES	
1. County Airport & Complex	Logan
2. Consolidated High School & Vocational/Athletic Complex	Welch
3. Consolidated High School	Coal City
4. Church: Protestant	Beckley

*Adopted from Reference No. 3.

TABLE 64. (CONT'D.) ALTERNATIVE USES OF SOME RECLAIMED SURFACE MINES*

IV. RECREATIONAL (public and private)	LOCATION
Mountaintop Recreational Lake	Middlesboro
V. MISCELLANEOUS	
1. Sanitary Landfill	Buckhannon
2. Sanitary Landfill	Rainelle
3. Sanitary Landfill	Walkersville
4. Sanitary Landfill	Boone County
5. Sanitary Landfill	Fayette County

*Adopted from Reference No. 3.

SECTION 8

PROJECT STATUS PHASE III

INTENSIVE SITES

Kentucky - Mine Site LA

After numerous discussions with mining company personnel and site visits in eastern Kentucky, Mine Site LA was chosen for intensive monitoring and evaluation. This site will be mined using conventional contour strip mining with associated head-of-hollow fills and truck haulback.

The premine plan specifies five head-of-hollow fills to be constructed in one relatively small watershed, thereby giving excellent flexibility in the monitoring program to accommodate any unexpected changes in mining plans. The following is a summary of our monitoring program up to January, 1977:

TABLE 65. TIME TABLE OF EVENTS FOR MINE SITE LA

Month	Event
April, 1976	• Site selected • Initial grab water samples • Aquatic biota assessment
May, 1976	• Monitoring station established Flow - Parshall flume - Steven's Water Level Recorder Water Sampler - Isco Auto Water Sampler
June, 1976	• All monitoring equipment's calibration checked • Isco sampler set to collect 110 ml/6 hours and composite 4 samples per bottle

Month	Event
July, 1976	• Routine month Since May, daily water samples have been composited into weekly samples (based on flow) and a monthly composite sample Samples are sent to a laboratory for analyses as soon as possible after collection • Water quality analyses Weekly composite samples, Group A, (Table 66) Monthly composite samples and monthly grab samples, Group B, (Table 66) • Site inspection
August, 1976	• Routine month Water quality sampling Site inspection • Aquatic biota sampling
September, 1976	• Routine month Water quality sampling Site inspection
October, 1976	• Mining started on Mine Site LA • Sediment pond constructed • Routine sampling month Water quality Site inspection
November, 1976	• Aerial photography of Mine Site LA taken at 2.5 cm = 61 m (1" = 200') Black and white stereo Color Color infrared • Routine month Water quality sampling of effluent from sediment pond was initiated Pond effluent analyzed weekly for Group C monthly composite Group B (Table 66)
December, 1976	• Head-of-hollow fill operation began in the monitored area • Routine month Water quality sampling

Month	Event
January, 1977	• Severe cold weather - influent water stream became frozen • Water samples are grab samples only

The intensive monitoring program for the head-of-hollow fill in Kentucky is on schedule with no major problems.

TABLE 66. WATER QUALITY ANALYSES

Type Analyses	Frequency	Source	Parameters
Group A	Weekly Composite	Influent	pH Alkalinity (total) Acidity (hot) Iron (total) Turbidity Sulfate Solids (total)
Group B	Monthly Composites	Influent Effluent	pH Alkalinity (total) Acidity (hot)
	Monthly Grab	Influent	Iron (total) Turbidity Sulfate Solids (suspend) Solids (total) Calcium Magnesium Manganese Aluminum Copper Zinc Cadmium Nickel Iron (dissolved) Specific Conductance

Type Analyses	Frequency	Source	Parameters
Group C	Weekly Grab	Effluent	Turbidity Total Suspend Solid

West Virginia

Selection of an intensive mine site in West Virginia was much more difficult than finding the Kentucky site. Difficulty centered around the following:

- Compatible time schedule - most mines do not know a year in advance where they will be mining.
- Mine size - compatible with project requirements.
- Mine site physical condition, mining techniques and overall reclamation practices - compatible with Phase II results.

Mine Site SA was finalized as West Virginia's intensive monitoring location for mountaintop removal and head-of-hollow fill; however, this did not occur until August, 1976. Two other sites had been selected earlier only to be deleted in the last stages of negotiations.

Although the West Virginia monitoring schedule is four months behind Kentucky's, this should not adversely affect the project. Mining is not to begin on this site until spring of 1977, permitting at least six months of baseline data to be obtained, approximately what was taken in Kentucky.

Mine Site SA is mountaintop removal mining with head-of-hollow spoil disposal. The terrain and geological condition are quite similar to Mine Site PA described in Section 6 of this report.

All equipment, sampling procedures, and analyses utilized in the Kentucky monitoring site hold true for this site investigation. The following is a summary of our monitoring programs up to January, 1977:

TABLE 67. TIME TABLE OF EVENTS FOR MINE SITE SA

Month	Event
August, 1976	• Site selected • Initial grab water samples
September, 1976	• Monitoring station established Flow - Parshall flume - Steven's Recorder Water Samples - Isco Auto Sampler
October, 1976	• Routine month Water quality samples • Flash flood Monitoring station silted in
November, 1976	• Aerial photography of Mine Site SA taken at 2.5 cm = 61 m (1" = 200') Black and white stereo Color Color infrared • Monitoring station moved up the hollow 366 meters (1,200 feet) to protect it from further flash floods • Water quality sampling continued
December, 1976	• Routine month Water quality Site inspection
January, 1977	• Severe cold weather - monitoring unit frozen

All water quality samples obtained are handled in the same manner as previously described (Table 66) for weekly and monthly composite baseline samples. The monitoring equipment is located between the toe of the proposed fill and the sediment control pond (Kentucky and West Virginia sites).

Currently, the West Virginia monitoring program is back on schedule and operating without any major problems.

REFERENCES

1. "Compilation of Air Pollutant Emission Factor", U.S. Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning and Standards, Publication No. AP-42, (1973).

2. Cowherd, C. Jr., et al, "Development of Emission Factors for Fugitive Dust Sources", Environmental Protection Agency, (1974).

3. Greene, B. C., "Productive Aspects of Reclaimed Surface Mined Lands", Department of Natural Resources, pp. 36-38.

4. Johnstone, H. F., W. E. Winsche, and L. W. Smith, "The Dispersion and Deposition of Aerosols", Chemical Review 44(2), p. 353, (1949).

5. Locasse, J. L. and W. J. Moroz (editors), "Handbook of Effects Assessment - Vegetation Damage", Center for Environmental Studies, The Pennsylvania State University, (1969).

6. McCormack, D. E., "Soil Reconstruction: Selecting Materials for Placement in Mine Reclamation", Mining Congress Journal, September, 1976, p. 36.

7. Mallary, R. and C. Carlozi, "The Aesthetics of Surface-Mine Reclamation: An On-Site Survey in Appalachia", Publication R-76-5, University of Massachusetts, (1976).

8. Pasquill, F., "The Estimation of Dispersion of Windborne Material", Meterorological Magazine, Volume 90, No. 1063, pp. 33-49, (1961).

9. Roberts, J. C., et al, "Preparation of Plans", Division of Design Guidance Manual, p. 27, (1975).

10. Ibid.

11. Roberts, J. C., et al, "Roadway and Drainage Excavation", Standard Specifications for Road and Bridge Construction, pp. 102-103, (1976).

12. Turner, D.B., "Workbook of Atmospheric Dispersion Estimates", AP-26, Environmental Protection Agency, (1970).

APPENDIX

TABLE 68. CLIMATOLOGICAL CONDITIONS FOR MINE SITE FA

YEAR	MONTHS	TEMPERATURE °C (°F)			PRECIPITATION CM (IN)			DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		MAX.	*MIN.*	*MEAN*	*TOTAL*	*DAILY MAX.*	*NO. OF PREC. DAYS*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	***FEBRUARY***	23 (74)	-9 (16)	9 (48)	5.54 (2.18)	3.38 (1.33)	10	57	73.81 (29.06)	55	7.9 (4.9)	24	
	MARCH	28 (82)	-3 (26)	12 (53)	13.26 (5.22)	2.92 (1.15)	17	70	73.71 (29.02)	55	5.3 (3.3)	26	
	APRIL	31 (87)	1 (34)	15 (59)	0.99 (0.39)	0.36 (0.14)	6	44	73.76 (29.04)	38	3.1 (1.9)	31	
	MAY	31 (87)	3 (38)	18 (63)	14.05 (5.53)	4.14 (1.63)	13	63	73.51 (28.94)	59	2.7 (1.7)	31	
	JUNE	32 (90)	10 (50)	23 (74)	8.79 (3.46)	4.24 (1.67)	15	50	73.66 (29.00)	60	1.9 (1.2)	28	
	JULY	34 (93)	14 (58)	25 (76)	9.53 (3.75)	3.89 (1.53)	13	53	73.71 (29.02)	62	3.4 (2.1)	28	
	AUGUST	33 (91)	13 (56)	24 (75)	5.03 (1.98)	2.72 (1.07)	10	49	73.81 (29.06)	60	5.1 (3.2)	02	
	SEPTEMBER	32 (89)	7 (44)	20 (68)	7.29 (2.87)	2.79 (1.10)	12	61	73.71 (29.02)	64	3.4 (2.1)	36	
	OCTOBER	27 (80)	-3 (27)	13 (55)	13.54 (5.33)	3.53 (1.39)	12	57	73.76 (29.04)	63	3.4 (2.1)	35	
	NOVEMBER	22 (71)	-9 (16)	6 (43)	8.76 (3.45)	6.25 (2.46)	8	54	73.86 (29.08)	52	5.0 (3.1)	28	
	DECEMBER	20 (68)	-12 (11)	3 (38)	11.23 (4.42)	2.34 (0.92)	15	53	73.79 (29.05)	60	5.0 (3.1)	28	
1977	***JANUARY***	9 (49)	-18 (-1)	-3 (27)	6.48 (2.55)	2.03 (0.80)	18	64	73.74 (29.03)	63	6.0 (3.7)	27	

TABLE 69. CLIMATOLOGICAL CONDITIONS FOR MINE SITE GA

YEAR	MONTHS	TEMPERATURE °C (°F)			PRECIPITATION CM (IN)			DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		MAX.	*MIN.*	*MEAN*	*TOTAL*	*DAILY MAX.*	*NO. OF PREC. DAYS*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	*FEBRUARY*	23 (73)	−15 (5)	7 (44)	11.86 (4.67)	7.39 (2.91)	14	70	73.69 (29.01)	57	10.1 (6.3)	22	
	MARCH	27 (81)	−7 (19)	10 (50)	9.45 (3.72)	2.72 (1.07)	17	69	73.61 (28.98)	59	9.8 (6.1)	21	
	APRIL	29 (84)	−4 (24)	13 (55)	3.15 (1.24)	1.63 (0.64)	5	49	73.74 (29.03)	45	3.7 (2.3)	21	
	MAY	29 (84)	0 (32)	16 (61)	8.03 (3.16)	1.91 (0.75)	16	51	73.48 (28.93)	51	2.3 (1.4)	18	
	JUNE	32 (89)	10 (50)	22 (71)	8.48 (3.34)	1.50 (0.59)	13	65	73.65 (28.99)	58	3.9 (2.4)	17	
	JULY	33 (92)	12 (53)	23 (73)	17.12 (6.74)	7.16 (2.82)	11	56	73.65 (28.99)	60	4.5 (2.8)	22	
	AUGUST	32 (89)	11 (51)	22 (71)	3.20 (1.26)	1.02 (0.40)	7	54	73.84 (29.07)	54	3.7 (2.3)	6	
	SEPTEMBER	29 (85)	3 (38)	18 (64)	10.74 (4.23)	3.61 (1.42)	11	57	73.72 (29.02)	60	1.4 (0.9)	11	
	OCTOBER	26 (78)	−7 (20)	10 (50)	9.80 (3.86)	2.26 (0.89)	12	58	73.74 (29.03)	62	1.3 (0.8)	15	
	NOVEMBER	18 (64)	−16 (4)	3 (37)	1.14 (0.45)	0.33 (0.13)	9	52	73.76 (29.04)	50	8.5 (5.3)	23	
	DECEMBER	16 (61)	−18 (0)	−1 (31)	3.10 (1.22)	1.73 (0.68)	12	57	73.69 (29.01)	63	7.7 (4.8)	22	
1977	*JANUARY*	6 (42)	−24 (−12)	−8 (18)	5.84 (2.30)	1.50 (0.59)	20	67	73.66 (29.00)	67	9.0 (5.6)	23	

TABLE 70. CLIMATOLOGICAL CONDITIONS FOR MINE SITE IA

YEAR	MONTHS	TEMPERATURE °C (°F)			PRECIPITATION *CM (IN)*			DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		MAX.	*MIN.*	*MEAN*	*TOTAL*	*DAILY MAX.*	*NO. OF PREC. DAYS*				*SPEED KPH (MPH)*	*DIRECTION*	
1976	***FEBRUARY***	25 (77)	-13 (8)	8 (46)	6.05 (2.38)	2.79 (1.10)	14	74	74.04 (29.15)	52	7.9 (4.9)	24	
	MARCH	28 (83)	-4 (24)	11 (52)	9.91 (3.90)	3.20 (1.26)	17	72	74.02 (29.14)	49	6.4 (4.0)	25	
	APRIL	32 (89)	-4 (25)	13 (56)	1.88 (0.74)	0.94 (0.37)	8	58	74.12 (29.18)	36	3.7 (2.3)	30	
	MAY	31 (88)	2 (36)	17 (63)	6.12 (2.41)	1.73 (0.68)	16	71	73.89 (29.09)	44	1.8 (1.1)	27	
	JUNE	33 (91)	10 (50)	22 (72)	10.80 (4.25)	2.64 (1.04)	13	68	74.04 (29.15)	55	1.9 (1.2)	19	
	JULY	33 (92)	12 (53)	23 (73)	13.92 (5.48)	5.33 (2.10)	12	67	74.02 (29.14)	60	5.1 (3.2)	25	
	AUGUST	33 (91)	10 (50)	22 (72)	14.53 (5.72)	4.45 (1.75)	11	66	74.24 (29.23)	55	1.4 (0.9)	07	
	SEPTEMBER	28 (83)	4 (39)	17 (63)	10.85 (4.27)	3.68 (1.45)	15	68	74.09 (29.17)	63	0.6 (0.4)	28	
	OCTOBER	27 (80)	-4 (24)	10 (50)	14.07 (5.54)	3.94 (1.55)	14	71	74.12 (29.18)	59	1.4 (0.9)	32	
	NOVEMBER	22 (72)	-12 (10)	4 (39)	1.85 (0.73)	0.81 (0.32)	13	57	74.12 (29.18)	45	7.7 (4.8)	27	
	DECEMBER	16 (61)	-14 (6)	0 (32)	5.51 (2.17)	1.91 (0.75)	17	68	74.04 (29.15)	57	6.3 (3.9)	28	
1977	***JANUARY***	6 (42)	-25 (-13)	-7 (20)	6.15 (2.42)	1.40 (0.55)	23	69	74.02 (29.14)	66	9.2 (5.7)	27	

TABLE 71. CLIMATOLOGICAL CONDITIONS FOR MINE SITE HA

YEAR	MONTHS	TEMPERATURE °C (°F)			PRECIPITATION CM (IN)			DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		MAX.	MIN.	MEAN	TOTAL	DAILY MAX.	NO. OF PREC. DAYS				SPEED KPH (MPH)	DIRECTION	
1976	FEBRUARY	21 (70)	-18 (-1)	6 (42)	7.52 (2.96)	1.73 (0.68)	18	72	69.65 (27.42)	58	12.7 (7.9)	23	
	MARCH	26 (78)	-9 (15)	9 (48)	8.43 (3.32)	2.39 (0.94)	17	74	69.65 (27.42)	54	9.7 (6.0)	22	
	APRIL	30 (86)	-8 [illegible]	[illegible] (52)	0.71 (0.28)	0.33 (0.13)	9	49	69.75 (27.46)	39	7.2 (4.5)	27	
	MAY	27 (80)	0 (32)	14 (57)	9.63 (3.79)	2.72 (1.07)	16	71	69.60 (27.40)	53	4.7 (2.9)	22	
	JUNE	29 (84)	7 (44)	19 (67)	7.57 (2.98)	1.85 (0.73)	14	71	69.85 (27.50)	56	5.0 (3.1)	16	
	JULY	31 (87)	8 (47)	20 (68)	9.04 (3.56)	3.61 (1.42)	13	70	69.80 (27.48)	58	6.6 (4.1)	25	
	AUGUST	29 (85)	6 (43)	19 (66)	4.42 (1.74)	1.32 (0.52)	12	61	70.00 (27.56)	59	0.3 (0.2)	22	
	SEPTEMBER	27 (81)	4 (39)	16 (60)	14.00 (5.51)	3.25 (1.28)	16	71	69.83 (27.49)	63	3.1 (1.9)	24	
	OCTOBER	22 (71)	-8 (18)	8 (46)	14.94 (5.88)	3.28 (1.29)	17	65	69.72 (27.45)	66	2.9 (1.8)	24	
	NOVEMBER	18 (64)	-14 (6)	1 (34)	3.30 (1.30)	0.99 (0.39)	17	63	69.60 (27.41)	58	11.1 (6.9)	26	
	DECEMBER	14 (58)	-17 (2)	-1 (30)	7.04 (2.77)	1.63 (0.64)	23	55	69.52 (27.37)	65	10.9 (6.8)	25	
1977	JANUARY	6 (42)	-28 (-18)	-8 (17)	5.13 (2.02)	1.12 (0.44)	25	59	69.32 (27.29)	74	13.0 (8.1)	26	

TABLE 72. CLIMATOLOGICAL CONDITIONS FOR MINE SITE MA

YEAR	MONTHS	TEMPERATURE °C (°F)			PRECIPITATION CM (IN)			DAYTIME CLOUD COVER %	AVERAGE BAROM. PRESSURE CM (IN)	1 P.M. RELATIVE HUMIDITY %	RESULTANT WIND		COMMENTS
		MAX.	MIN.	MEAN	TOTAL	DAILY MAX.	NO. OF PREC. DAYS				SPEED KPH (MPH)	DIRECTION	
1976	**FEBRUARY**	26 (78)	-15 (5)	8 (46)	5.36 (2.11)	1.63 (0.64)	16	70	73.76 (29.04)	49	8.7 (5.4)	24	
	MARCH	29 (84)	-6 (22)	11 (52)	10.69 (4.21)	3.61 (1.42)	15	67	73.74 (29.03)	53	7.4 (4.6)	23	
	APRIL	31 (88)	1 (33)	17 (62)	9.30 (3.66)	2.90 (1.14)	15	63	73.61 (28.98)	46	3.9 (2.4)	25	
	MAY	33 (91)	-5 (23)	13 (55)	1.27 (0.50)	0.58 (0.23)	8	45	73.84 (29.07)	40	5.1 (3.2)	27	
	JUNE	34 (94)	8 (47)	22 (72)	10.77 (4.24)	3.58 (1.41)	15	65	73.79 (29.05)	51	2.6 (1.6)	21	
	JULY	34 (93)	11 (51)	22 (72)	17.60 (6.93)	7.39 (2.91)	15	61	73.74 (29.03)	56	5.1 (3.2)	24	
	AUGUST	33 (91)	7 (45)	21 (70)	5.66 (2.23)	2.21 (0.87)	12	57	73.99 (29.13)	56	1.0 (0.6)	36	
	SEPTEMBER	30 (86)	4 (40)	17 (63)	13.64 (5.37)	3.99 (1.57)	16	63	73.81 (29.06)	58	2.4 (1.5)	26	
	OCTOBER	26 (78)	-6 (21)	10 (50)	13.82 (5.44)	2.72 (1.07)	17	67	73.83 (29.07)	59	2.7 (1.7)	27	
	NOVEMBER	21 (69)	-11 (12)	3 (38)	2.59 (1.02)	0.66 (0.26)	17	56	73.81 (29.06)	50	8.5 (5.3)	25	
	DECEMBER	16 (61)	-15 (5)	-1 (31)	5.54 (2.18)	1.04 (0.41)	17	64	73.76 (29.04)	58	6.9 (4.3)	27	
1977	**JANUARY**	7 (44)	-23 (-10)	-7 (19)	4.83 (1.90)	0.84 (0.33)	23	70	73.69 (29.01)	68	9.7 (6.0)	26	